Updated for the PMBOK® Guide 6th Ed.

CAPM® in Depth

Certified Associate in Project Management Study Guide for the CAPM® Exam

Second Edition

Paul Sanghera

Apress®

CAPM® IN DEPTH

CERTIFIED ASSOCIATE IN PROJECT MANAGEMENT STUDY GUIDE FOR THE CAPM® EXAM

SECOND EDITION

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Printed on acid-free paper

To my wife, Renee, and our son, Adam.

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About the Author

Dr. Paul Sanghera is a leading expert in project management. He is a scientist, engineer, teacher, manager, and author. He has years of diverse hands-on project management experience, both in academic research labs—from Cornell to CERN—and in the high-tech computer industry—from Novell to Netscape to MP3. Having worked in various roles, including project manager, director of project management, director of software development, software developer, teacher and trainer, and scientist, Dr. Sanghera has developed a broad and deep comprehension of the global principles of project management applicable to all areas. In addition to authoring or coauthoring more than 150 science research papers published in American, Canadian, European, and other international research journals, Dr. Sanghera has authored several books in science, technology, and project management.

Introduction

"Begin at the beginning, and go on till you come to the end: then stop."

—*Alice's Adventures in Wonderland* by Lewis Carroll

The primary purpose of this book is to help you pass the Certified Associate in Project Management (CAPM) exam administered by the Project Management Institute (PMI). The exam, and hence this book, is based on the sixth edition of the PMBOK Guide. Because this book has a laser-sharp focus on the exam objectives, expert project managers and project team members who want to pass the CAPM exam can use this book to ensure that they do not miss any objectives. Yet this is not an exam-cram book. The chapters and the sections within each chapter are presented in a logical learning sequence. A topic in a chapter and the chapter only depend upon the previously covered topics and chapters, and there is no hopping from topic to topic. The concepts and topics, both simple and complex, are clearly explained when they appear for the first time. No prior knowledge of project management is assumed. This facilitates stepwise learning, prevents confusion, and makes this book useful also for beginners who want to get up to speed quickly to pass the CAPM exam, even if they are new to the discipline of project management. The presentation of material in such a fashion enables the book to help a wider audience, as noted next.

Who This Book Is For

With a focus on the CAPM exam topics, this book is designed to serve the following audiences:

- Project management practitioners who want to prepare for the CAPM exam
- Entry-level project managers and project team members who want to prepare for the CAPM exam
- Beginners who want to join the field of project management and get up to speed quickly

- Project managers who want a book to use as a quick and easy reference to the discipline of project management
- Instructors and trainers who want a textbook for a course on introductory project management for both exam and non-exam classes

How the Book Is Organized

This book tells the story of project management in a cohesive and concise yet comprehensive fashion. This book is written to the most current version of the CAPM exam based on the sixth edition of *A Guide to the Project Management Body of Knowledge* (PMBOK Guide) by PMI. The discipline of project management, according to the PMBOK Guide, contains ten knowledge areas, such as cost management and quality management, and five process groups: initiating, planning, executing, monitoring and controlling, and closing. The CAPM exam is solely based on the PMBOK Guide, which is organized along the knowledge areas. To keep things simple for the reader, I have also organized this book along the knowledge areas. The project management processes in one knowledge area interact with processes in other knowledge areas. That said, all efforts have been made to keep the presentation cohesive. All concepts are explained where they appear for the first time. All sections in a chapter and all chapters in the book are logically connected to each other to support sequential learning. To support this effort, the book is organized into four parts.

A glossary at the end of the book covers all the important concepts and can be helpful for a quick check of a term at any stage of your reading.

How Each Chapter Is Organized

Each chapter begins with a list of the exam objectives on which the chapter is focused. The first section in each chapter is an introduction in which we establish three or four underlying concepts or topics that will be explored in the chapter. Each chapter has the following features:

- **Exam Objectives.** All exam objectives covered in the chapter are fully explained at the beginning of the chapter.
- **Big Picture.** Each chapter begins by introducing the big picture of the topics covered in the chapter. This prepares the reader for a smooth dive into the details, which follow.

- **Study Checkpoints.** Each chapter in its body presents Study Checkpoints, which are exercises to ensure that you get the crucial points in the covered material. The solutions to Study Checkpoints are presented in Appendix A.
- **Notes, Tips, and Cautions.** As you read through a chapter, you will find *Notes* that present additional helpful material related to the topic being described, *Tips* that provide additional real-world insight into the topic being discussed, and *Caution*s on the points that would be easy to trip on for some.
- **Summary.** The "Summary" section of each chapter provides the big, unified picture while reviewing the important concepts in the chapter in a very concise way.
- **Exam's Eye View.** The "Exam's Eye View" section highlights the important points in the chapter from the perspective of the exam: the things that you must comprehend, the things that you should watch out for because they might not seem to fit in with the ordinary order of things, and the facts that you should memorize for the exam.
- **Review Questions.** Each chapter ends with a "Review Questions" section that has a two-pronged purpose: to help you test your knowledge of the material presented in the chapter and to help you evaluate your ability to answer the exam questions based on the exam objectives covered in the chapter. The answers to the review questions are presented in Appendix B.

About the CAPM Exam

This book covers the material for the CAPM exam. Passing this exam is necessary to obtain CAPM certification.

To be eligible to take the CAPM exam, you must meet a set of minimum requirements. A summary of these requirements and other details is listed in the following table.

The CAPM Exam at a Glance

Exam Detail	CAPM
Number of questions	Scorable: 135 Pretest: 15
Maximum time allowed	3 hours
Question types	Multiple choice
Minimum educational background	High school diploma or global equivalent
Minimum project management experience	1,500 hours of professional experience on a project team or 23 contact hours of formal project management education
Exam fee (given in U.S. dollars—may vary by country)	Member: $225 Non-member: $300
Sign code of professional conduct	Yes

Note For the most up-to-date and detailed information, visit the PMI website at www.pmi.org, or see the latest version of the *CAPM Certification Handbook* by PMI.

The following are a few tips that you can use both while you are preparing for the exam and during the exam:

- PMBOK has a very formal way of naming processes, process groups, knowledge areas, and documents. Know these formal names well. However, just like in real-life project management, do not expect that the exam will always refer to these names in a formal way. To help you on this issue, this book refers to these names in both formal and informal ways. For example, performing quality control (informal) means the Control Quality process (formal), scope plan (informal) means project scope management plan (formal), and initiating (or initiation) means Initiating Process Group.
- The questions in the CAPM exam are largely based on the PMBOK Guide, Sixth Edition. Still, you need to read the questions carefully and patiently and figure out what counts and what does not, and if there is some extra information.

- Get comfortable with the idea that there will be some questions that you may not be able to answer correctly. In such a situation, just believe in yourself and your experience and select the best answer accordingly. You may have the option (read the instructions before starting the exam) to leave these questions for a possible review later if you have time. Key point: Move on without getting frustrated.
- There will be questions for which you will need to choose between an innocent way of skipping the formal process to save time and following the formal project management process. In almost all cases, the correct answer will be to follow the process.
- There will be questions for which you will need to choose between facing the problem head-on and taking an easy way out, such as dodging a thorny issue, ignoring a challenging problem, or postponing a difficult decision. Almost always, the correct answer is to meet the problem head-on in a professional manner.
- To answer some questions correctly, understand that in the world of project management as seen from the perspective of PMBOK, project managers communicate directly and clearly and do not say things to be read between the lines. For example, if you have a problem with a team member, you talk to the team member face-to-face rather than going to the member's manager, which you might need to do eventually if you can't solve the problem by dealing directly with the team member.
- Understand clearly the roles of the key stakeholders, such as the project manager, project sponsor, and customer. Especially understand your responsibilities as a project manager. You need to be proactive to make decisions and manage the project, influence the factors that contribute to changes rather than waiting for the changes to occur, and have up-to-date information about the project.

- Know the details of the input, output, and tools and techniques for each process, not just the names. For example, it's not enough to remember that the project management plan is an input to a process. You should know the project management plan is an input because it contains such and such subsidiary plans from which such and such information is used in this process. Be prepared to see the subsidiary plan as an input in the answer options, whereas the PMBOK Guide might have listed the project management plan as an input.

Best wishes for the exam; go for it!

—Paul Sanghera, Ph.D.

PART

I

The Big Picture of Project Management

Welcome to the world of project management. Here is project management for you in five simple concepts: initiate, plan, execute, monitor and control, and close.

The rest is in the details. We start this journey by presenting the big picture of project management—exploring the project management framework and the environment in which the project is performed and overviewing project management via all five stages of the project: initiate, plan, execute, monitor and control, and close.

CHAPTER

1

Project Management Framework

The objectives covered in this chapter make up 6 percent of the CAPM exam, equivalent to about eight questions.

Study the whole chapter in detail. The concepts involved may not be mentioned directly in the exam objectives, but you will need them in order to answer the questions correctly.

CAPM Exam Objectives

1. Understand the five project management process groups and the processes within each group.
2. Recognize the relationships among project, program, portfolio, and operational management.
3. Define a typical project lifecycle.
4. Understand the function and importance of tailoring for different projects.

P. Sanghera, *CAPM® in Depth*, https://doi.org/10.1007/978-1-4842-3664-2_1

What do the Eiffel Tower, the Internet, and this book have in common? Projects! All three of them are outcomes of projects. Even given all the required material and knowledge, how do people really build immense and complex structures or systems, such as the Eiffel Tower of Paris, the Taj Mahal of Agra, or the Internet and the World Wide Web of the Information Age? The answer is again *projects*. Through projects, it is possible to build small and big and simple and complex things in an effective and efficient manner. All projects need to be managed. A so-called unmanaged project is simply a poorly managed project that is destined to fail. Therefore, the importance of project management cannot be overstated.

We all know from experience that each project has (or should have) a beginning and an end. Therefore, managing a project means managing the lifecycle of the project, starting from the beginning (initiating) and going to the end (closing); this is accomplished using processes, which constitute what are called *project management knowledge areas*. Although you use your knowledge in terms of processes to manage projects, the management will be greatly influenced by the environment in which the project runs, such as the structure and culture of the performing organization. Projects also originate from their environments.

The goal of this chapter is to walk you through the framework of project management. To that end, we will explore three avenues: the project lifecycle, the project management knowledge areas, and the project in the context of programs, portfolios, and the organization's strategy. In the process of doing so, we will introduce some basic concepts of project management.

Basic Concepts in Project Management

Each discipline of knowledge, from physics to biology and from computer science to poetry, builds upon some basic concepts. The terms that refer to or define these concepts make up the language of the discipline. The very basic terms in project management are described briefly in the following list:

- **Project.** A project is a work effort made over a finite period of time with a start and a finish to create a unique product, service, or result. Because a project has a start and an end, it is also called a *temporary effort* or *endeavor*.
- **Project Phase.** A project phase is a set of logically related activities that usually completes one or more major deliverables of the project. The phases are generally completed in sequence; however, an overlap is possible in some situations. Depending on its size and complexity, a project may have one or more phases.

- **Project Life Cycle.** It is the full project duration from beginning to end, including all project stages: initiating, planning, executing, monitoring and controlling, and closing. If projects have multiple phases, all of these stages are repeated in each phase.
- **Process Groups.** These are the technical names for the project stages: initiating, planning, executing, monitoring and controlling, and closing.
- **Organization.** An organization is a group of individuals organized to work for some purpose or mission. Computer companies, energy companies (to whom you pay your electric bills), and cable companies are examples of organizations. An organization might offer products, such as books or donuts, or services, such as Internet access or online banking.
- **Performing Organization.** The performing organization, also referred to as the project organization, is the organization that is performing the project.
- **Project Stakeholder.** A project stakeholder is an individual or an organization that can affect or be affected by the project execution. A project can have a wide spectrum of stakeholders, from the project sponsor, to an environmental organization, to an ordinary citizen.
- **Process.** In the context of projects, a process is a set of related tasks performed to manage a certain aspect of a project, such as cost, scope, and risk. Each process belongs to a knowledge area and corresponds to a process group.
- **Knowledge Area.** A knowledge area in project management is defined by its knowledge requirements related to managing a specific aspect of a project, such as cost, by using a set of processes. PMI recognizes a total of nine knowledge areas, such as cost management and resource management.
- **Tailoring.** Obviously, you don't apply all the project management knowledge to a project. For a given project, with help from the project team, you select appropriate lifecycle phases and needed outputs, and to produce those outputs you choose the right processes, inputs, and tools and techniques. This method is called tailoring.

- **Project Management.** Project management is the use of knowledge, skills, and tools to manage a project from start to finish with the goal of meeting the project requirements. It involves using the appropriate processes.
- **Phase Gate.** A review at the end of each phase leading to the decision to continue to the next phase as planned, continue to the next phase with changed plan, or end the project.

This is a minimal set of terms that you need to understand before you can start your exploration of the world of project management. More terms will be introduced as you continue exploring the discipline of project management in this book.

Now that you understand these basic terms, you can ask a very basic question: What does it mean to manage a project? In other words, what's involved in managing a project?

Understanding Projects

Before delving into the details of project management, you need to understand what a project is, where it came from, and why. At any organization, there are many activities being executed every day. Most of these activities are organized into groups of interrelated activities. These groups fall into two categories: projects and operations. An operation is an ongoing and repetitive set of tasks, whereas a project has a lifecycle—a beginning and an end.

What Is a Project?

A project is a work effort made over a finite period of time with a start and a finish to create a unique product, service, or result. Because a project has a start and a finish, it is also called a *temporary effort* or *endeavor*. In other words, as the PMI defines it, "a project is a temporary endeavor undertaken to create a unique product, service, or result." So, a project has two defining characteristics: it is temporary, and it creates a unique product. Let's explore further these two defining concepts: temporary and unique.

Temporary. The temporary nature of projects refers to the fact that each project has a definite beginning and a definite end. A project can reach its end in one of two possible ways:

- The project has met its objectives—that is, the planned unique product has been created.
- The project has been terminated before its successful completion for whatever reason.

Note that the temporary nature of a project does not mean that the project will be of short duration, nor does it refer to the product it creates. Projects can create lasting products, such as the Taj Mahal, the Eiffel Tower, or the Internet.

The second defining characteristic of a project is that it must create a unique product.

Unique product. The outcome of a project must be a unique product, service, or result. How do a product, service, and result differ from each other?

- **Product.** This is a tangible, quantifiable artifact that is either the end item or a component of it. The big-screen television in your living room, the Swiss watch on your wrist, and the wine bottle on your table are some examples of products.
- **Service.** Actually, when we say a project can create a service, we really mean the capability to perform a service. For example, a project that creates a website for a bank to offer online banking has created the capability to offer the online banking service.
- **Result.** This is usually the knowledge-related outcome of a project—for example, the results of an analysis performed in a research project.

In this book, quite often we will refer to product, service, or result as just "product" or "project outcome" for brevity.

Caution! Not only organizations undertake projects. A project can also be undertaken by a group of individuals or even a single individual.

Projects are organized to execute a set of activities that cannot be addressed within the limits of the organization's ongoing normal operations. To clearly identify whether an undertaking is a project, you must understand the difference between a project and an operation.

Distinguishing Projects from Operations

An organization executes a multitude of activities as part of the work to achieve objectives. Some of these activities are to support projects, and others are to support what are called *operations*. An operation is a set of tasks that does not qualify to be a project. In other words, an operation is a function that performs ongoing tasks. It does not produce a unique (new) product, and it does not have a preplanned beginning and end. For example, to put together a data center is a project, but after you put it together, keeping it up and running is an operation.

It is important to understand that projects and operations share some characteristics, such as the following:

- Both require resources, including human resources, i.e., people.
- Both are constrained to limited, as opposed to unlimited, resources.
- Both are managed—that is, planned, executed, and controlled.
- Both have objectives and contribute to meeting the company's strategic objectives.
- Both can have and share stakeholders.

The distinctions between projects and operations can be made by sticking to the definition of a project—that it is temporary and unique. Operations are generally ongoing and repetitive. Although both projects and operations have objectives, a project ends when its objectives are met, whereas an operation continues contributing to objectives—and possibly to a new set of objectives in the event of a change in the organization's strategy.

Projects can be performed at various levels of an organization; they vary in size and accordingly can involve just one person or a team. Table 1-1 presents some examples of projects.

Table 1-1. Examples of Projects

Project	Outcome (Product, Service, or Result)
Constructing Eiffel Tower	Product
Running presidential election campaign	Results: win or lose; Products: documents
Developing a website to offer online education	Service
Setting up a computer network in one building	Service
Moving a computer network from one building	Result: network is moved to another building
Study the genes of members of Congress	Results (of the research); Product: research paper
Book sold in a bookstore	Product
A software app like MS Word sold as a CD and paid for once	Product
A software app integrated into web and paid for monthly	Service
Human Genome Project	Result

STUDY CHECKPOINT 1.1

Identify each of the following items as a project or an operation.

A. A librarian performing her daily job responsibilities

B. A bookseller processing customer orders

C. A network administrator ensuring that the network stays up and running 24/7

D. Taking a course in molecular biology

A project can result in a product (or service) that is sustained by an operation. For example, constructing the Eiffel Tower is a project, whereas managing it for the tourists visiting it every day is an operation.

Now that we have a clear idea of what a project is, we have to wonder why an organization would launch a specific project. So, let's ask a fundamental question: Where do projects originally come from?

Origins of Projects: Where Do Projects Come From?

Projects are originated by organizational leaders in response to one or more situations the organization is facing. These situations, or factors acting on the organization, may fall into one of the following four categories:

1. **Business/legal requirements.** This category includes projects based on the need of meeting legal, regulatory, or social requirements. For example, consider a building owner authorizing a project to make the building accessible to physically disabled persons in order to meet the legal requirements for using the building for a specific business.
2. **Stakeholder requests or needs.** This category includes projects based on satisfying stakeholder requests or needs. An example would be an environmental organization starting a project to raise awareness among politicians about the science behind global warming issues. Another example would be a company that undertakes a project to lessen the negative impact that its operations or products may have on the environment.
3. **Business or technological strategies.** This category of factors would give rise to projects based on the need to implement or change business or technological strategies. For example, a web design company authorizes a project to automate certain aspects of maintaining websites to increase its efficiency and revenue. For another example, based on recent technological advances, a taxi company might start a project to implement an automatic driving feature in some of its taxis.
4. **Products, processes, or services.** This category of factors would give rise to projects based on the need to create, improve, or fix products, processes, or services. For example, a biotechnology company authorizes a project to produce and implement SOP (standard operating system) in all its labs.

As a careful reader would note, these four categories of factors specified by PMI are not mutually exclusive. For example, the last category is at least partially redundant; a project in response to any of these categories may create a product or service. For this reason, or as a result of the objectives of the project, the project may fall into more than one of these categories.

For example, a car manufacturer's project to make electric cars using cutting-edge technology in response to environmentally aware customers' needs falls into all of the last three categories: 2, 3, and 4.

These categories of factors collectively are called project initiation context. As illustrated in Figure 1-1, these factors are linked, on one hand, to the strategic objectives of the organization and influence its business strategy, and on the other hand are linked to the business value of the organization though projects. In short, an organization with a certain business value, responding to one or more of these factors, runs a project that produces some business value, adding to the previous business value of the organization. This is how projects bring about change—by driving the organization from a lower business-value state to a higher business-value state—and in this way help the organization to stay viable.

Note The strategy of an organization is an action plan to achieve its business goals and objectives. It's also called the *strategic plan* or *strategic business plan*. The strategy determines the portfolio of projects and programs that the organization will execute.

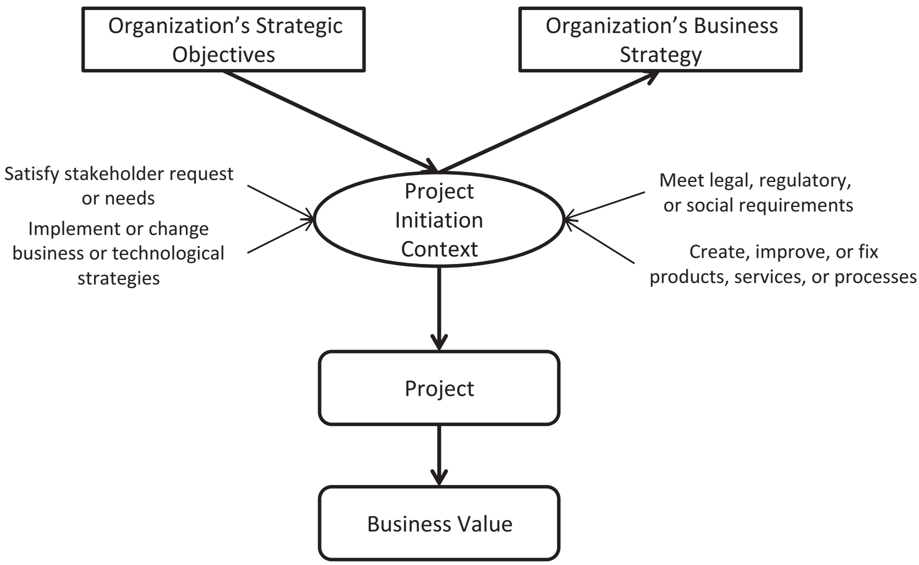

Figure 1-1. Origination of a project and its single most important outcome: business value added to the organization

Caution! The factors discussed in this section not only influence the organization's current business strategies but also its current operations because operations are there to serve business strategies or objectives.

In addition to the initiation context discussed here, in the next chapter, we will explore what other organizational and external factors may influence the project.

Where there is a project, there is project management.

Understanding Project Management

In this book, we refer to project management as defined in the project management standard by the Project Management Institute (PMI): "Project management is the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements."

This standard, contained in the *Project Management Body of Knowledge* (PMBOK) *Guide*, presents, as PMI claims, "a subset of the project management body of knowledge that is generally recognized as good practice." By *generally recognized*, PMI means two things: 1) the presented knowledge is applicable to most projects most of the time; and 2) there is consensus about its value and usefulness. The *good practice* is also the general consensus that the application of the presented knowledge, skills, tools, and techniques to project management processes can enhance the probability of project success.

Note As a result of innovation and advances in science and technology, the body of knowledge in the project management profession is constantly changing, so the standard is updated accordingly every few years.

In a poorly managed project, bad things happen to the project, such as missed deadlines, cost overruns, and poor quality, all resulting in dissatisfied project stakeholders. This will essentially fail the project and hurt the organization's reputation and viability. However, effective project management helps to manage different aspects of project, such as cost, scope, and stakeholders making the project more predictable as it's being executed. This helps to identify and resolve problems and issues—as well as to identify and respond to risk—in a timely fashion, increasing the chances of project success. Moreover, with effective project management, you can clearly link the project result to the business goals of the organization, which will enable you to adjust the project plans in a changing business environment. This way, effective project

management helps the organization to persist in a fast-changing world by staying relevant and viable. In this book, *project management* means *effective* project management until mentioned otherwise.

Projects are inseparable from project management. At initiating time, a project is just born, and it's brought up by a procedure called *progressive elaboration* through project management.

Understanding Progressive Elaboration

As the saying goes, Rome was not built in a day. Rest aside, the product of a project—even the project plan—is not built in a day either. Usually there is a concept first and a broad vision for the end product—that is, the outcome of the project. The clearer the vision you have of the unique product that you want from the project, the more accurate the project plan will be. So, you move toward the project plan in incremental steps as the ideas about the final product are refined and as you get more and more information about the requirements in a progressive fashion. This procedure of defining (or planning) a project is called *progressive elaboration*.

Here is an example of progressive elaboration. You wake up one morning with an idea to close the digital gap in your community. Now, you have a concept of the final product (result) of your project: close the digital gap in your community. But what do you really mean by that? It might include many things—building computers in an economical way and providing them at low prices to those who don't have them, raising awareness of the necessity of computer literacy, offering classes, and the like. Now, you are really working to refine your idea of the final product. The second question is, how are you going to do this? Here, you are referring to the project plan. You can see that the project plan and its accuracy and details depend upon how refined the idea of the final product is. The final product or objectives and the plan to achieve them will be elaborated further in smaller steps.

Tip Uncontrolled changes that make it into the project without being properly processed are called *scope creep*. Do not confuse progressive elaboration with scope creep.

Progressive elaboration, in general, means developing something in incremental steps. The project plan will be broadly defined to start and will get more accurate, detailed, and explicit in an incremental fashion as better understanding about the project deliverables and objectives develops. It involves successive iterations of the planning process, which result in a more accurate and complete plan.

Even after you have an approved final project plan and the project starts executing, progressive elaboration continues to some extent. For example, you will see later in this chapter that the execution and planning stages of the project interact with each other. Based on project performance and stakeholder requests the project plan could change, even including project scope.

Most of project management is done by performing a set of processes.

Understanding a Process

Processes are the heart of project management. In other words, processes are atoms, the smallest functional units, of project management. If you want to think of project management like a project management professional, think in terms of processes. Almost everything in the world of project management is done through processes.

What is a process, anyway? Back up a little and look around you; you will see processes everywhere, not only in project management. For example, when you make coffee in the morning, you go through a process. The water, the coffee filter, and the roasted hazelnut coffee made by grinding golden-colored beans are the input items to this process. The coffeemaker is the tool, and how you make the coffee is the technique. A cup of freshly brewed hazelnut coffee is the output item from this process. So, a process, in general, is a set of interrelated activities performed to obtain a specified set of products, results, or services. A project management process, as explained in the example and in Figure 1-2, always consists of three parts: input, tools and techniques, and output. If you like this analogy, think of a process as a chemical reaction in which tools and techniques operate on input to produce an output. The term *raw data* in Figure 1-2 means that the input is processed to produce output.

Input	**+**	**Tools and Techniques**	**→**	**Output**
Raw data or information for the process	Tools and techniques operate on input	Appropriate tools and techniques	Produces	The outcome of the operation of tools and techniques on input data or information

Figure 1-2. Three parts of a process: tools and techniques operating on input to produce output

Of course, you can come up with other examples of processes that you have been using in your life without realizing it. In project management, you use processes to accomplish things, such as developing a project schedule, directing and managing the project work, and developing and managing the project team.

Tip As phase is the atom of a project, process is the atom of project management.

As illustrated in Figure 1-2, each process consists of three parts, described in the following list:

- **Input.** The input to a process consists of the raw data—the data or information that is needed to start the process and that will be processed into output. For example, the project management plan is one of several input items in the Develop Schedule process that will be used to develop the schedule of a project.
- **Tools and Techniques.** Tools and techniques are the methods used to operate on the input to transform it into output. For example, a critical path method that helps to develop a schedule is a tool used in the schedule development process.
- **Output.** The output is the outcome or result of a process. Each process contains at least one output item; otherwise, there would be no point in performing a process. For example, an output item of the schedule development process is, well, the project schedule.

Now that you understand what a process is, you likely realize that you will be using different processes at different stages (not phases) of a project, such as planning and execution. Actually, the whole lifecycle of a project can be understood in terms of five stages, with each stage corresponding to a group of processes.

Caution! An organizational operation may also have some kinds of processes, but that does not make the operation a process.

The following are some characteristics of processes:

1. **Iterations**. Some processes, such as Develop Project Charter and Close Project, are run only once or at predetermined points in the process, while others, such as Conduct Procurements and Acquire Recourses, may be periodically run depending on the project size. Yet processes like Define Activities may be even more frequently performed.
2. **Process Interconnect**. Processes are connected with other processes by input or output. An output item of a process becomes an input to an other process or a terminal output; i.e., a project or phase deliverable.
3. **Overlapping**. Some of the input items may appear in multiple projects. This is also true for tools or techniques. From this, you can see that processes may overlap in their activities.

Now that we have a very good basic idea of projects, we can take a tour of the project lifecycle.

Understanding the Project Lifecycle

As you already know, each project has a beginning and an end. The timespan from the project's beginning to its end is called the *project lifecycle*. If a project has multiple phases, all the phases are completed during its lifecycle to complete the project. Regardless of whether the project has multiple phases or just one phase, during this lifecycle the project is started, organized and prepared for, carried out (project work is performed), watched over, and closed. In the standard terminology, a project is initiated, planned, executed, monitored and controlled, and closed.

Caution! Do not confuse *project lifecycle* with *product lifecycle*. A project is executed to create a product or products, which lasts after the project is finished. In general, the project lifecycle is contained within the lifecycle of each product it creates. For example, a project creates a product that lasts for a certain time after the project ends, and then it retires. As another example, a project is run to add features to a product that existed before the project was initiated and lasts after the project is completed.

From initiation/authorization to completion/closure, a project goes through a whole lifecycle that includes defining the project objectives, planning the work to achieve those objectives, performing the work, monitoring and controlling the progress, and closing the project after receiving product acceptance. Figure 1-3 shows the different stages of the project lifecycle; the arrows indicate the flow of information. The five stages, technically called *process groups*, of a project lifecycle are described in the following list.

Caution! I refer to the five process groups as five stages for the purpose of helping you visualize a project. Technically and in PMBOK, they are called *process groups*. However, be prepared to recognize them regardless of how they are referred to in the exam; do not expect the exam to always refer to a process group or a document by its formal technical name. This is also true with the real world out there, where you will be performing projects.

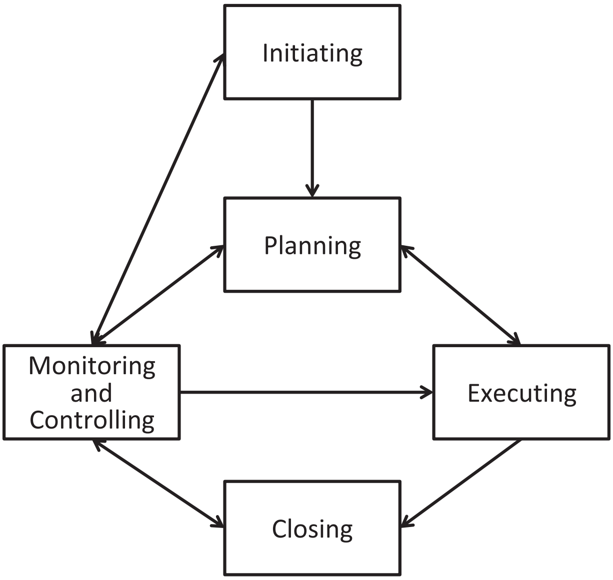

Figure 1-3. Different stages in the lifecycle of a project. Each of these stages represents a process group.

Initiating a Project

This stage defines and authorizes the project. The project manager is named and the project is officially launched through a signed document called the *project charter*, which is a high-level document that contains items such as the purpose of the project, a product description, project objectives and requirements, and a summary of the milestone schedule. The central purpose of this stage is to align the project's purpose with the business needs and the organization's business strategy on one hand and with the stakeholders' expectations on the other.

It is good policy to involve customers and other important stakeholders in the initiating stage of the project. It will give them a feeling of shared ownership that will greatly contribute to the success of the project by positively influencing factors such as acceptance of deliverables and stakeholder satisfaction.

Note In the discipline of project management, like in many other disciplines, the term *high-level* means lacking details or not referring to details. Keep this meaning in mind when you read terms in this book such as *high-level product description*, *high-level plan*, and the like. Details are usually worked out through a process called *progressive elaboration*.

Caution! The processes in the initiating process group, just like those in any other process group, can also be used to initiate a phase of a project that has multiple phases.

After the project has been initiated, it needs planning.

Planning the Project

In this stage, you, the project manager, along with the project management team, develop the project scope, define and refine the project objectives, and develop activities to meet those objectives. You do this by developing the project management plan, which is a collection of several plans and other documents that constitute the course of action required to achieve the objectives and meet the requirements of the project. The processes used to perform this stage fall into a group called the *planning process group*. In this process group, some non-plan documents are also developed for the project.

The approved scope plan, schedule plan, and cost plan are called the scope baseline, schedule baseline, and cost baseline, respectively. These three baselines together are called the project baseline or the performance measurement

baseline (PMB). The project performance at any time is assessed by comparing the results from project execution against this performance measurement baseline (PMB). In other words, to see how the project is performing, you compare the actual project execution results against this baseline.

Note The project management plan contains plans from various project management areas called subsidiary plans, such as a project scope management plan, a schedule management plan, and a quality management plan.

You then execute the project as planned.

Executing the Project

In this stage, you, the project manager, manage the execution of the project as planned in the project management plan. You coordinate all the activities being performed to achieve the project objectives and meet the project requirements. Of course, the main output of this project is the project deliverables. Approved changes, recommendations, and defect repairs are also implemented in this stage. The stakeholders can also suggest changes, which must go through an approval process before implementation. The project execution is performed using processes that fall into a group called the *executing process group*.

So, the project work defined in the project management plan is executed by using the processes found in the executing process group. The processes in this group are used to accomplish a three-pronged goal:

- Coordinate people and resources used to perform the project activities.
- Integrate and manage the project activities being performed.
- Ensure the implementation of the project scope and approved changes.

The lion's share of project resources is consumed in performing processes from the executing process group.

Note Performing processes from the executing process group may also generate change requests, which must be processed for approval in the monitor and control group.

Where do the changes and recommendations implemented in this stage come from? They arise from monitoring and controlling the project. In general, the execution of the project needs to be monitored and controlled to ensure the project stays on the planned track.

Monitoring and Controlling the Project

You monitor and control the project throughout its lifecycle, including during the executing stage. The purpose of monitoring and controlling is to make sure that the project stays on track, i.e., is performed as planned, and, if it goes off track, to take action to bring it back on track. To accomplish this, you continually perform the following steps:

1. Collect the actual project performance data.
2. Analyze it to compare the results against the project performance baseline to measure project deviation from the plan.
3. Based on deviation, generate change requests, e.g.; recommend preventive and corrective actions, and process them for approval followed by implementation.

Change requests may also come directly from the stakeholders, and should also be properly evaluated and processed. You will do all this using the processes that fall into the process group called the *monitoring and controlling process group*.

Note Monitoring and controlling does not start only after the project begins execution. Rather, the project needs to be monitored and controlled all the way from initiation through closing.

Whether completed or terminated, each project needs to be closed properly.

Closing the Project

In this stage, you verify that all the required project processes are complete, all project-related contracts are closed, the outcome of the project is turned over to another group, and you can bring the project to an end by disbanding the project team. Closing the project also includes conducting a project review for lessons learned. Don't forget the last—but not least—task of the closing stage: celebration. Terminated projects (that is, projects canceled before completion) should also go through the closing stage. The processes used to perform the closing stage fall into the *closing process group*.

In a multi-phase project, each phase can and should be closed using the same process used to close the project.

■ **Note** What we refer to as project stages here are not the project phases. A project phase is a part of the whole project in which certain milestones or project deliverables are completed. All these stages, technically called *process groups*, can be applied to any phase of a project that is divided into multiple phases.

■ **Note** The processes of the closing process group can be used to close a project, as well as to close a phase of a project.

Each process is a two-dimensional entity. It belongs to both a certain project stage (group) and a specific process knowledge area.

Understanding Project Management Knowledge Areas

To manage projects, you use project management knowledge, which is categorized into multiple aspects; each category is called a project management knowledge area. For example, each project has a scope that needs to be managed, and the knowledge required to manage scope is in the knowledge area called *project scope management*. To perform the project work within the project scope, you need resources, which need to be managed; the knowledge area used to manage human resources is called *resource management*. You get the idea. Each process belongs to one of the ten knowledge areas discussed in the following list.

1. **Project integration management.** The project is initiated, planned, and executed in pieces using different knowledge areas, and all those pieces are related to each other and need to be come together. That is where integration management comes in. For example, coordinating efforts to develop and integrate different subsidiary plans into the project management plan needs to be managed. In general, the integration management knowledge area offers processes to define, identify, coordinate, and integrate various activities and processes within each project management process group.

   In this book, we discuss project integration management in Chapter 3.

2. **Project scope management.** The primary purpose of project scope management is to ensure that all the required work, and only the required work, is performed to complete the project. Scoping a project is like drawing boundaries around it delineating what is included in the project and what is not. During scope management, you develop the scope baseline, one of the three very important project baselines, the other two being schedule baseline and cost baseline.

   In this book, we discuss project scope management in Chapter 4.

   The work included in the project scope needs to be scheduled.

3. **Project schedule management.** The primary purpose of project schedule management is to develop and manage the project schedule so as to complete the project in time as planned. It contains processes to generate information needed to develop the schedule, a process to develop the schedule, and a process to control the schedule. During schedule management, you develop the schedule baseline, one of the three very important project baselines, the other two being scope baseline and cost baseline.

   In this book, project schedule management is covered in Chapter 5.

   Resources are needed to complete the project activities in the project schedule.

4. **Project resource management.** The primary purpose of project resource management is to identify, obtain, and manage the resources needed to complete the project. The term *resources* resources refers to both human resources, e.g.; project team, and physical resources, i.e., material, equipment, facilities, and infrastructure. This includes the processes used to obtain, develop, and manage the project team that will perform the project work.

   Project resource management is discussed in Chapter 6.

   All the project resources cost money.

5. **Project cost management.** The primary task of project cost management is to estimate and control the project costs, and the primary goal is to complete the project within the approved budget. During cost management, you develop the cost baseline, one of the three very important project baselines, the other two being scope baseline and schedule baseline.

   We cover project cost management in Chapter 7.

   We do all these and other project management tasks for project stakeholders.

6. **Project stakeholder management.** The primary purpose of project stakeholder management is to identify project stakeholders and manage and monitor their engagement in the project. This involves analyzing their potential impact on the project and their expectations from the project, and accordingly developing a strategy to appropriately get them engaged in the project.

   In this book, project stakeholder management is covered in Chapter 8.

   Not only in project stakeholder management, but in managing all aspects of the project, you need to communicate.

7. **Project communication management.** It is absolutely imperative for the success of the project that project information is generated and distributed, i.e., communicated, in a timely fashion. Some would say communication is the most important aspect of a project and the most important skill for a project manager to have. Without a doubt, it is a critically important component of project management and a common thread that runs through the project lifecycle.

   This process group offers three processes: plan communication to determine communication approach; manage communication to make it happen; and monitor communication to ensure it happened. The key to a project and the mantra of effective communication is the distribution of the right information to the right stakeholders at the right time by using the right communication methods to create the desired impact. To make that happen, you need be able to create, store, and retrieve information.

Project communication management is discussed in Chapter 9.

Any project is complete only to the degree to which its objectives and requirements are met; this refers to the project quality, which needs to be managed, too.

8. **Project quality management.** This process group offers three processes to manage quality: plan quality to determine the quality requirements and standards that are relevant to the project at hand; manage quality to ensure that the planned quality requirements and standards are applied; and control quality to verify that the project and its deliverables meet the quality requirements and conform to the quality standards.

   We discuss project quality management in Chapter 10.

   We make assumptions and estimates and face constraints. These sources of uncertainty can give rise to risks, which must be managed.

9. **Project risk management.** A project risk is an event that, if it occurs, has a positive or negative effect on meeting the project objectives. The primary purpose of project risk management is to identify risks and respond to them should they occur. To make that happen, this project group offers processes to identify, analyze, plan and implement responses to, and monitor risks. It also contains a process used to plan risk management.

   In this book, project risk management is covered in Chapter 11.

   There will be situations in which your organization does not have the expertise to perform certain schedule activities in-house. For this or other reasons, you might want to acquire some items or services from an outside vendor. This kind of acquisition is called *procurement*, and it also needs to be managed.

10. **Project procurement management.** The primary purpose of procurement management is to manage the acquisition of products (that is, products, services, or results) from outside the project team in order to complete the project. The external vendor who offers the service is called the *seller*.

As you have seen, managing a project largely means performing a set of processes at various stages of the project, such as initiating and planning. Accordingly, processes are grouped corresponding to these stages, and these groups are called *process groups*. Processes are also part of the knowledge required to manage projects. Each of these processes belongs to one of the ten knowledge areas identified in the *PMBOK Guide*, *Sixth Edition*. So, a process has a dual membership—one in a process group, indicating at what stage of the project the process is performed, and the other in a knowledge area, indicating what aspect of the project is managed by using the process. Table 1-2 shows this dual membership for all the processes identified in the *PMBOK Guide*.

Table 1-2. Mapping of the Project Management Processes to Process Groups and Knowledge Areas

Process Groups => Knowledge Areas || V	Initiating Process Group	Planning Process Group	Executing Process Group	Monitoring and Controlling Process Group	Closing Process Group
Integration Management (3)	Develop Project Charter	Develop Project Management Plan	1. Direct and Manage Project Work 2. Manage Project Knowledge	1. Monitor and Control Project Work 2. Perform Integrated Change Control	Close Project or Phase
Scope Management (4)	—	1. Plan Project Scope Management 2. Collect Requirements 3. Define Scope 4. Create Work Breakdown Structure	—	1. Validate Scope 2. Control Scope	—
Schedule Management (5)	—	1. Plan Schedule Management 2. Define Activities 3. Sequence Activities 4. Estimate Activity Resources 5. Estimate Activity Durations 6. Develop Schedule	—	Control Schedule	—
Resource Management (6)	—	1. Develop Resource Plan 2. Estimate Activity Resources	1. Acquire Resources 2. Develop Team 3. Manage Team	Control Resources	

(continued)

Table 1-2. *(continued)*

Process Groups => Knowledge Areas || V	Initiating Process Group	Planning Process Group	Executing Process Group	Monitoring and Controlling Process Group	Closing Process Group
Cost Management (7)	—	1. Plan Cost Management 2. Estimate Costs 3. Determine Budget	—	Control Costs	—
Stakeholder Management (8)	Identify Stakeholders	Plan Stakeholder Engagement	Manage Stakeholder Engagement	Monitor Stakeholder Engagement	
Communications Management (9)	Identify Stakeholders	Plan Communications	1. Distribute Information 2. Manage Stakeholder Expectations	Report Performance	
Quality Management (10)	—	Plan Quality Management	Manage Quality	Control Quality	—
Risk Management (11)		1. Plan Risk Management 2. Identify Risks 3. Perform Qualitative Risk Analysis 4. Perform Quantitative Risk Analysis 5. Plan Risk Responses	Implement Risk Responses	Monitor Risks	—
Procurement Management (12)	—	Plan Procurement Management	Conduct Procurements	Control Procurements	

STUDY CHECKPOINT 1.2

What is the core difference between knowledge areas and process groups? Try to answer this question in one sentence.

Note Not all the processes are used in all projects. The project management team decides which processes need to be used in a given project.

STUDY CHECKPOINT 1.3

In the following table, match each item in the first column with a corresponding item in the second column:

Knowledge Area	Action
A. Message	1. While developing the schedule, Lora realized that there was a risk involved in the project. So, she put her thoughts into a note that she wrote on her computer.
B. Scope	2. Manage interdependencies among different processes belonging to different knowledge areas.
C. Cost	3. Ensure the project includes the work required to complete the project successfully and no extra work.
D. Schedule	4. Plan the schedule and complete the project within the planned schedule.
E. Quality	5. Plan the budget, track what you are spending, and complete the project within budget.
F. Risk	6. Ensure that you develop the right product that will satisfy the needs for which the project is undertaken.
G. Procurement	7. Obtain the team to do the project work and lead and motivate the team to keep working in the right direction in an efficient and effective way.
H. Resources	8. Generate and distribute the required project information to the right stakeholders at the right time by using the right method.
I. Communication	9. Plan for uncertain events that could happen and deal with them when they do happen in such a way that possible benefit is maximized and damage is minimized.
J. Integration	10. Identify the project work that needs to be contracted out of the performing organization and contract it out.

Once you enter the field of project management you will immediately run into two neighbors of a project: the program and the portfolio. Your project may be standalone, part of a program, or belong to a portfolio.

Triangular Relationship: Project, Program, and Portfolio

As a project manager, you should know the basic concepts of programs and portfolios and how they are related to each other and to projects. The real action to obtain the goals and objectives of an organization always happens at the project level, but for good reasons a project may be run as part of a program or portfolio; the two structures are described in the following.

Program. A program may be defined as a set of interrelated projects all working toward the same set of objectives. These projects are put into a program to reap the benefits of managing them in a coordinated way that would not be available by managing them individually. For example, a publication company may put several science book development projects into one program and a set of web-development projects related to marketing, sales, and learning into another program.

A program may also be a part of a higher-level program. Both project and subprograms within a program are referred to as program components. Just as a project is managed by a project manager, a program is managed by a program manager, who oversees program components and manages project-level aspects. Program management focuses on optimally managing the interdependencies among the projects in the program in order to keep the program and project goals and objectives aligned with the strategic goals and objectives of the organization. Program managers also make sure that program benefits and project benefits are both realized. In addition, the program manager's responsibilities also include:

- Make sure that the program scope flows appropriately into program components and manage interdependencies among the program components to best meet program objectives, and accordingly allot the budget to the program components.

- Resolve resource conflict and constraints that affect the program components and manage change requests about the shared governance framework.
- Resolve program-level issues between component projects and also resolve constraints and conflicts that affect projects within the program.
- Manage program risks that may impact program components.

Portfolio. A portfolio is a higher-level structure that may contain projects, programs, subportfolios, and operations and is managed by a portfolio manager. These components are put together in a portfolio to facilitate effective management in order to implement the strategic business plan of the organization.

Caution! The portfolio components, programs, or projects may or may not be interdependent or directly related.

Portfolio management is the centralized management of one or more portfolios in which portfolio components are managed at the portfolio level to achieve specific strategic business objectives. A portfolio is an interface of the firm's projects and programs to its strategy. Portfolio management focuses on making sure that programs and projects are prioritized for resources to serve the organization's strategy. Therefore, investment decisions are usually made at the portfolio level. One task of portfolio management is to select the optimal set of programs and projects to meet the strategic objectives, on one hand, and to increase the likelihood of realizing the desired return on investment, on the other hand. It also provides centralized management of the aggregate risk of all profile components.

To understand the relationship of a portfolio with projects and programs, note the following:

- Even if an organization does not have any programs and has only individual projects, all these projects can be grouped into one or more portfolios.
- If an organization has programs and no individual projects external to all programs, all these programs can be grouped into one or more portfolios.
- If an organization has some programs and some individual projects, all these programs and projects can be grouped into one or more portfolios.

■ **Caution!** Projects, programs, and portfolios have different lifecycles and focuses and different sets of objectives, and hence different sets of activities to meet those objectives and different sets of resulting benefits. However, they may share the same resources serving the same stakeholder. This underlies the importance of intraorganization coordination to avoid and resolve conflicts.

Figure 1-4 shows the triangular relationship among portfolios, programs, and projects; in the figure, an arrow represents containment. As the figure illustrates, all portfolios are composed of programs, projects, or both. A program consists of only projects and not portfolios. The figure also illustrates that both a program and a portfolio can have projects. That means a project may have membership in a portfolio directly or through a program. What is not shown in this simple figure that a program may have subsidiary programs and a portfolio may contain subsidiary portfolios and operations.

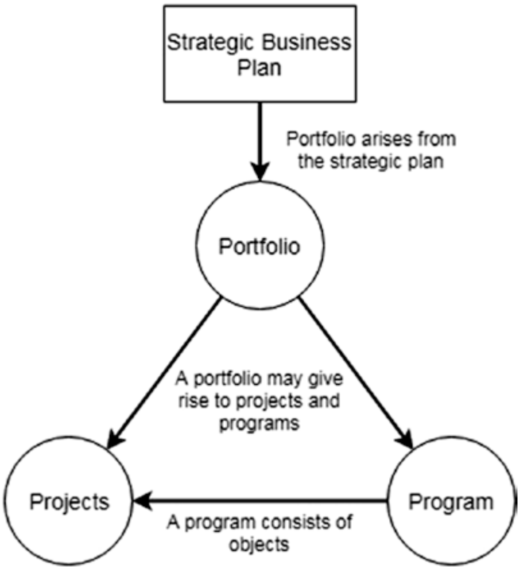

Figure 1-4. Triangular relationship between projects, programs, and portfolios

As compared to projects and programs, a portfolio is closer to an organization's business objectives, and therefore this is where most of the investment decisions are made. If you want to learn about an organization's business intent and direction (or strategy), look at its portfolio. It's also important to note that a portfolio can include operational work as part of its structure.

Table 1-3 presents a comparison between some characteristics of projects, programs, and portfolios.

Table 1-3. Comparison Between Projects, Programs, and Portfolios

Characteristic	Project	Program	Portfolio
Definition	Endeavor with beginning and end to create a unique product, service, or result.	Group of related projects and subsidiary programs managed together to reap the benefits not available from managing them individually.	Collection of projects, programs, subsidiary portfolios, and other related work managed together to meet the strategic objectives.
Management	Project manager manages the project, including project team, to lead the project to success by meeting project objectives.	Program manager manages the program by coordinating the program components' activities to ensure the delivery of planned program benefits.	Portfolio manager performs general portfolio management that may include managing or coordinating the portfolio management staff and also the program and project staff with reporting responsibility to portfolio.
Scope	Project scope limited to meeting its objectives; developed throughout the project lifecycle.	A program's scope affects and encompasses the scopes of the program components aimed at meeting the program benefits in the context of the strategic goals of the organization.	Portfolios have an organizational scope to produce changes in the strategic objectives of the organization.
Planning	Project manager, from high-level information, develops detailed project plans by using progressive elaboration throughout the project lifecycle.	Program has high-level plan that includes tracking the progress and interdependencies of program components; this plan also provides guidance to plan at component level.	Portfolio manager performs planning at the portfolio level, which includes developing and executing necessary processes including communication in context of aggregate portfolio.
Change	Project manager expects change and performs processes to manage it.	Program manager adapts change to optimize the benefits from program components.	Portfolio manager monitors changes in the broader internal and external environment and responds to them to best serve the strategic plan of the organization.

(*continued*)

Table 1-3. (*continued*)

Characteristic	Project	Program	Portfolio
Monitoring	Project manager monitors and controls the project activities/processes to produce the planned products, results, or services of the project.	Program manager monitors the progress of program components to make sure the overall goals and benefits will be achieved within the planned budget and schedule.	Portfolio managers monitor strategic changes and resource allocation, performance results, and risk at the portfolio level.
Success	Success measured generally by quality of project and its product, level of customer satisfaction, and whether project completed within budget and time.	Program success measured by delivery of planned program benefit and the efficiency and effectiveness of the delivery.	Success relates to the overall portfolio performance, which is an aggregated investment compared to the overall benefit realized.

STUDY CHECKPOINT 1.4

Match each item in the first column of the following table with one or more suitable items in the second column.

Entity	May Contain
A. Project	1. Operations
B. Program	2. Projects
C. Portfolio	3. Programs
	4. Portfolios
	5. Activities to create a well-defined unique product

Throughout the book, you will be exploring the details of project management, and therefore getting introduced to some advanced concepts up front will make that journey more pleasant and smooth.

Some Common Concepts

Throughout this book, you will be encountering concepts such as probability, baseline, project team, and project management team. Those concepts are introduced in the following sections.

Probability-Related Concepts

The theory of probability has its early seventeenth-century roots in the investigations of games of chance, such as roulette and cards. Since then, a multitude of mathematicians and scientists have contributed to the development of the theory of probability. Today, the concepts of probability appear in almost every discipline, ranging from physics to project management. Risk (an important aspect of a project) and probability have the same origin: uncertainty. In project management, there is always an important question: What is the probability of this risk occurring? In the modern age, probability has already entered into folk psyche through phrases such as "What are the odds that this will happen?"

Probability. Probability is defined as a chance that something will happen. For example, when you play the lottery and you wonder what the odds are that you will win, you are thinking of probability. The simplest example of probability is tossing a coin. When you toss a coin, what is the probability that the coin will land heads up? When you toss a coin, there are only two possibilities: it will land either heads up or tails up. Each possibility is equally likely if you are not cheating. Therefore, the probability that the coin will land heads' up is 1 out of 2, or 50 percent, or 0.5. In general, if there are *n* possible outcomes of an event and each outcome is equally likely, then the probability of a specific outcome is 1/*n*.

Another useful concept in probability is the combined probability of several events. For example, if you toss two coins, the probability that first coin will land heads up and the second coin will land tails up is 0.5 x 0.5 = 0.25. In general, to calculate the combined probability, you multiply the individual probabilities. If the probability that an Event X will happen is A, the probability that Event Y will happen is B, and the probability that Event Z will happen is C, then the probability that all the three events (X, Y, and Z) will happen is A x B x C. To summarize, the probability that a number of independent events will occur is calculated by multiplying the probabilities of occurrence of all the individual events.

Random Variable. A random variable can acquire any value within a given range or out of a set of values. For example, you can use a random variable to represent the results of rolling a fair die, which has six sides numbered by dots from 1 to 6. The possible outcome of rolling a die could be any number from the set of outcomes: {1, 2, 3, 4, 5, 6}.

Expected Value. This is the expected value of an outcome. As an example, assume you get into a bet that you will win $10 if a coin toss results in heads, and you will lose $5 if it results in tails. Given that the probability for heads or tails is 0.5 for each, the expected value for the money that you will win is $10 x 0.5 = $5, and the expected value for the money that you will lose is $5 x 0.5 = $2.5.

Variance. The variance of a random variable is the deviation from the expected value. It is computed as the average squared deviation of each number from its mean. For example, assume that the values of a random variable are 2, 4, 5, 7, and 2 in five measurements. The mean value for these measurements is

$$(2+4+5+7+2)/5=4$$

The variance of the spread of these values is

$$V=\sigma^2=\left[(2-4)^2+(4-4)^2(7-4)^2(2-4)^2\right]/5=3.4$$

Standard Deviation. This is the square root of the variance—that is, σ. So, in our example, the standard deviation is the square root of 3.4—that is, 1.84.

Algebraic Equations. Project/program management and some questions in the CAPM, PMP, and PgMP exams will assume that you can do simple mathematical calculations. You should also have a very simple understanding of algebraic equations. You should be able to make simple manipulations, such as the following:

CPI=EV/AC implies EV=CPI × AC

CV=EV–AC implies EV=AC+CV

STUDY CHECKPOINT 1.5

You are about to throw a quarter and a dime several times. What is the probability of the following happening?

A. The quarter will land heads up on the first try.

B. The dime will land tails up on the first try.

C. The quarter will land heads up and the dime will land tails up on the first try.

D. Both the quarter and the dime will land heads up on the first try.

E. The quarter will land heads up on the first try and also heads up on the second try.

Global Project Variables

There are some significant factors in projects and project management that vary their values throughout the project lifecycle. You must keep your eye on these variables from the very beginning of the project:

- **Cost and number of team members (staff).** This is low in the beginning because the project is just in the preparation stage, reaches a maximum when the project is being executed—that is, when most work is done—and drops rapidly when the project draws to a close because most of the work has already have done.
- **Ability to influence the characteristics of the project product.** Your or any other stakeholder's ability to influence the project product characteristics without significantly changing the cost is the highest in the beginning because not much has been done yet in any direction. However, this ability gradually decreases as the project progresses because we have already invested in a given direction.
- **Risk and uncertainty.** This is highest in the beginning because there are plenty of unknowns and assumptions. It decreases as the project progresses as unknowns start disappearing and details start appearing as a result of the principle of progressive elaboration. This is true about both risk and uncertainty, as risks arise from uncertainty, which at least partially arises from assumptions.

STUDY CHECKPOINT 1.6

In the following table, match each item in the first column to the corresponding item in the second column.

Project Variable	Value
A. Level of staff	1. Highest in the beginning and end of the project and lowest when the project is being executed
B. Risk	2. Highest in the beginning and decreases as the project progresses
C. Ability to influence the characteristics of the project product without significantly impacting the project cost	3. Low in the beginning, maximum when the project is being executed
D. Cost	4. Uniform throughout the project

Baseline

The project baseline is defined as the approved plan for certain aspects of the project, such as the cost, schedule, and scope of the project. The project performance is measured against this baseline. The project baseline is also referred to in terms of its components—cost baseline, schedule baseline, and scope baseline. How do you know how the project is performing? You compare the performance against the baseline. Approved changes in cost, schedule, and scope will also change the baseline.

Big Picture of Project Management

In this chapter, you have learned what project management is and how project management is performed by applying knowledge and skills to project activities in order to meet project objectives. Applying knowledge boils down to performing processes. We have also learned that projects originate from the need to achieve the organization's strategic objectives, and they may come to you standalone or as parts of a program or a portfolio.

Figure 1-5 shows the big picture of project origin and project management in terms of projects, processes, the project lifecycle in terms of project stages, and the project aspects managed by ten different knowledge areas. There are ten important aspects of projects, and each of these ten aspects is managed by using the corresponding knowledge area. For example, cost is managed by using the cost management knowledge area, and communication is managed by using the communication management knowledge area. So, project management is performed by applying processes from certain knowledge areas at certain stages of the project.

The three most important takeaways from this chapter are as follows:

- A project, whether standalone or part of a program or a portfolio, is performed to contribute to meeting the strategic objectives of an organization.
- The project lifecycle consists of five stages, technically called process groups: initiating, planning, executing, monitoring and controlling, and closing. Depending on the project, these stages may repeat in different phases.
- The project processes that are performed to manage projects make up ten project management knowledge areas: integration management, scope management, time management, cost management, resource management, communication management, stakeholder management, quality management, risk management, and procurement management.

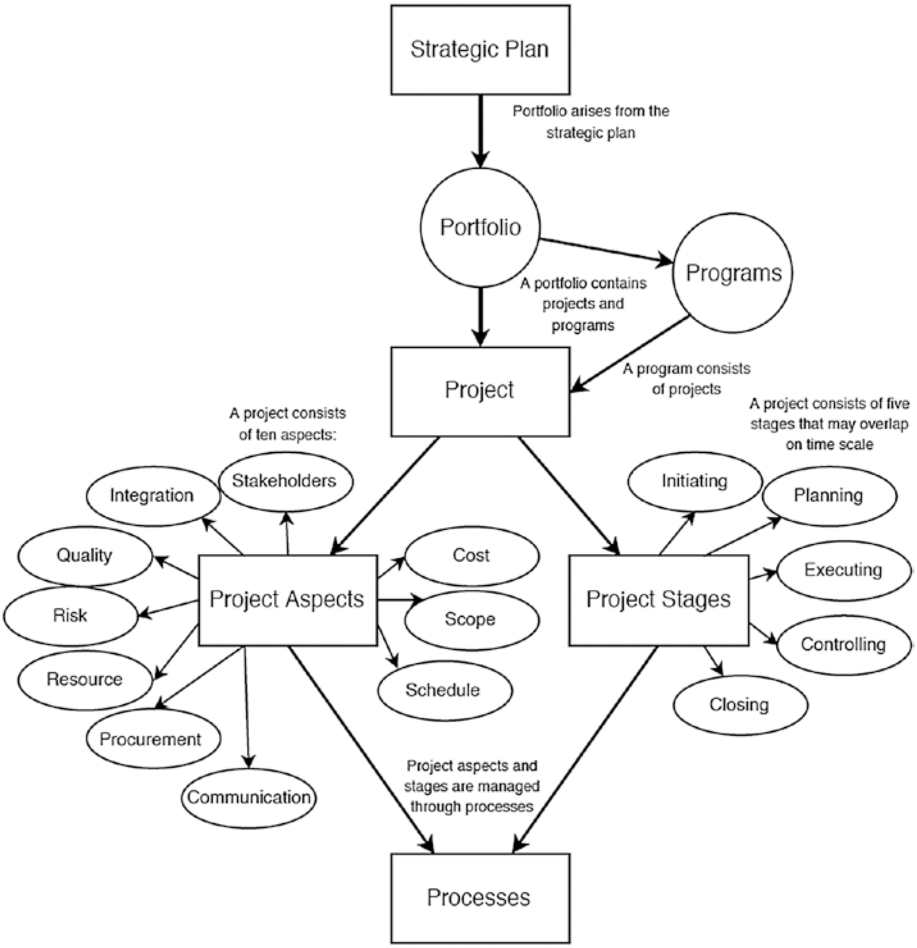

Figure 1-5. The big picture of project management: the aspects of a project that need to be managed at different stages of the project lifecycle by using processes

In nutshell, project management and processes performed in project management have two dimensions: knowledge and process group. This chapter presented a big picture of project management from a more theoretical perspective. A rather detailed big picture of project management from a more practical perspective is presented in Chapter 3, where we will explore the project integration knowledge area.

Summary

The business activities inside an organization are generally organized into groups, which fall into two categories—operations and projects. Operations usually consist of ongoing routine work, whereas a project has a goal to generate a unique product, service, or result in a finite time—that is, it has a planned beginning and a planned end. Organizations launch projects for different reasons, such as to meet a business or legal requirement or to take on an opportunity offered by the market. However, the underlying motivation behind taking on these opportunities is the business strategy of the organization. A project, like anything else in an organization, needs to be managed. Project management is the application of knowledge and skills to project activities in order to meet the project objectives. It involves performing a set of processes distributed over ten knowledge areas of project management: communication management, stakeholder management, cost management, resource management, integration management, procurement management, quality management, risk management, scope management, and schedule management. Each process is two dimensional: it is a part of a knowledge area and also has a membership in one of five process groups: initiating, planning, executing, monitoring/controlling, and closing. The process groups represent different stages of a project lifecycle.

A successful project completion adds to the organization's business value, and in this way changes the organization's business value state to a higher level. A project can be standalone or belong to either of two higher-lever entities: programs and portfolios. A program is a collection of interrelated projects and subsidiary programs and is performed to reap benefits that would not be available if the projects were managed individually. Programs have a closer view of the company's business strategy or strategic objectives than do the projects. A structure that is even closer to a company's strategy is the portfolio, which, in general, is a collection of projects, programs, subsidiary portfolios, and operations. A portfolio is a direct interface to the organization's business strategy.

Road Ahead. In this chapter, we explored the basic framework of projects and project management. Projects are born and managed in an environment constituted by factors within the performing organization and the outside world. We will explore that environment in the next chapter.

Exam's Eye View

Comprehend

- The way PMI views it: The discipline of project management is constituted by ten knowledge areas: scope management, cost management, resource management, quality management, risk management, schedule management, procurement management, communication management, stakeholder management, and integration management.
- Depending upon which stage of the project lifecycle they are executed in, the processes are grouped into five process groups: initiating, planning, executing, monitoring and controlling, and closing.
- A process belongs to exactly one knowledge area and one process group.
- The same input may appear in more than one process. This is also true for tools and techniques.
- An output from one project either becomes an input to another process or it's a terminal output; i.e., a project or phase deliverable.
- You do not have to perform all the processes in a project, and a process may be performed several times.
- Projects bring change to a company by adding to the company's business value, and in this way raise its business value state to a higher level.

Look Out

- For a work effort to be qualified as a project, it must be temporary (that is, have a start and a finish), and the outcome must be a unique product, result, or service. Routine, ongoing work is an operation, not a project.
- A project may vary in size—it may be a few days long or a few months long—and may involve one person or quite a few individuals.
- A big project is not called a program, but a megaproject.
- A project may or may not be a part of a program or a portfolio, but a program always consists of projects, or subsidiary programs, or both.
- A program may contain a subsidiary program, and a portfolio may contain a subsidiary portfolio and operation too.
- It's not necessary to perform all the processes for a project. Processes are selected to meet the needs of the project.

Memorize

- The ten knowledge areas and five process groups listed under the "Comprehend" section of this table.
- Process groups are not project phases. A phase contains all process groups.
- Organizations start projects in response to the factors acting on them, which can be categorized into four groups: business or legal requirements; stakeholder requests or needs; business or technological strategies; products, processes, or services.

Review Questions

1. Which of the following are the essential characteristics that make a group of activities a project?
   - A. It takes multiple individuals to perform these activities, and it creates a new product.
   - B. The work is managed by a project manager.
   - C. The group has a plan and a budget.
   - D. The group has a start date and a finish date, and its outcome will be a new product.
2. Which of the following is a project?
   - A. Running a donut shop
   - B. Building another library in your area, which might take a long time
   - C. Keeping a network up and running in a university department
   - D. Running a warehouse
3. Which of the following are the process groups?
   - A. Starting, planning, executing, monitoring and controlling, and closing
   - B. Initiating, organizing and preparing, executing, monitoring and controlling, and closing
   - C. Initiating, planning, implementing, monitoring and controlling, and closing
   - D. Initiating, planning, executing, monitoring and controlling, and closing
4. Which of the following is *not* a project management knowledge area?
   - A. Project procurement management
   - B. Project risk management
   - C. Project quality management
   - D. Project team management

5. Which of the following is the best definition of *progressive elaboration*?

   A. Taking the project from concept to project management plan

   B. Taking the project from conception to completion

   C. Taking the project from initiating to closing

   D. Decomposing the project objectives into smaller, more manageable work pieces

6. Your project depends on two business partners, On The Fly Inc. (OTF) and The Sure Thing Inc. (ST), delivering their products to you on time. The chances are three out of four that OTF will make the delivery on time and two out of three that ST will not make the delivery on time. The probability that OTF and ST will both deliver on time is equal to:

   A. 0.25

   B. 0.5

   C. 5/7

   D. 4/7

7. Both projects and operations share all the following characteristics except:

   A. Performed by individuals

   B. Planned, executed, monitored, controlled, and closed in a preplanned way

   C. Limited by constraints

   D. Performed to achieve the strategic objectives of the organization

8. You are being interviewed by a functional manager, who says, "We have this huge undertaking of launching an online education website that contains different components, such as designing the website, developing the content, developing the administrative system including registration and payment, marketing the courses on the website, integrating different components of the website, and finally going live. Each component is functionally

complex and large enough that it will be better served under a different management." The manager is most likely describing a:

A. Project

B. Program

C. Operation

D. Portfolio

9. Your company runs a website that makes digital music downloads available to end users. You have been assigned a project that involves adding parental guidance warnings to various downloads. This project originated due to which category of factors?

A. Social, regulatory, or legal requirements

B. Stakeholder requests or needs

C. Products, processes, or services

D. Business or technological strategies

10. Select each of the following that is a project management knowledge area:

A. Project integration management

B. Project scope management

C. Project communication management

D. Project time management

11. What is *not* true about project management processes?

A. Each process must be performed at least once in a project.

B. A process belongs to a knowledge area and also to a process group.

C. A process can be performed more than once in the same project.

D. A process is performed to accomplish a specific task of process management.

12. What is *not* true about project management processes?
    A. The same document may be an input to more than one process.
    B. The same tool or technique may be used in more than one process.
    C. The output of one process cannot be an input to another process.
    D. It's possible that a process will be executed only once in project and multiple times in another project.
13. As you have decided to outsource a piece of your project, you will conduct procurements using a process belonging to which process group?
    A. Executing
    B. Planning
    C. Monitoring and Controlling
    D. Initiating

CHAPTER

2

Project Environment

The objectives covered in this chapter make up 13 percent of the CAPM exam, equivalent to about 18 questions.

Study the whole chapter in detail. Some concepts involved may not be mentioned directly in the exam objectives, but you will need them in order to answer the questions correctly.

From Chapters 1 and 2, also internalize the concepts that project management processes interact with one another—e.g.; an output item generated by one process may become an input item for some other process—and that a tool or technique may be used in more than one process.

P. Sanghera, *CAPM® in Depth*, https://doi.org/10.1007/978-1-4842-3664-2_2

CAPM Exam Objectives

Project Environment:

1. Identify the factors and assets that may impact the outcome of a project.
2. Distinguish between organizational systems.
3. Understand the purpose and activities of a project management office.
4. Recognize the hierarchy of projects, programs, and portfolios.

Role of the Project Manager:

1. State the primary functions of a project manager.
2. Understand a project manager's sphere of influence.
3. Identify the major elements included in the PMI triangle.
4. Recognize the difference between leadership and management.

Although you use your knowledge in terms of processes to manage projects, the management will be greatly influenced by the environment in which the project runs, such as the structure and culture of the performing organization. Projects also originate from their environments.

In the previous chapter, you learned how the five process groups (which we also referred to, in this book, as the different stages of the project lifecycle) and the ten project management knowledge areas constitute the project management framework. The actual implementation of project management is greatly influenced by the facts on the ground—where the rubber hits the road. In other words, a given project is performed in a certain environment; e.g.; it runs in an organization with its own structure and culture, in a certain location with its own culture and laws. This part of the environment is called the enterprise environment factors (EEF). Now, the organization has some assets, such as knowledge, policy and procedures, and processes, to start the project and support it through its lifecycle. This part of the project environment is called the organizational process assets (OPA). In addition to these two components, we will add project stakeholders to the environment to complete the story.

This environment influences the project and therefore impacts it. In fact, a project is born in this environment and goes through it for its entire lifecycle. As they say in physics, action and reaction are equal and opposite. As a project is being influenced and impacted by its environment, it or its outcome influence and impact back some element of the environment. For example, a successful

project can change the business-value state of the organization to a higher level, and a project aimed at opposing a cultural trend or creating a new trend impacts the culture of a society.

The goal in this chapter is to explore how the project environment influences the project and hence project management. We will build this chapter on three basic concepts: influence, organizational systems, and project stakeholders.

Caution! You will hear an earful about two concepts, influence and impact, in this book and in project management, in general. So, it's important to get them right. Think of influence like a force, and when a force is applied to anything, it has an impact on that thing. The magnitude of the impact may vary depending on the situation.

Project Environment: Big Picture

As explained in Chapter 1, a project originates in response to a situation in order to fulfill the business need of an organization according to its strategy. The organization and its internal and external environments, e.g.; EEF and OPA, are already there and are where the project is born, as illustrated in Figure 2-1. The business need assessment leads to producing the two project management documents—i.e., the project business case and benefit management plan, which includes project objectives and success measures—which leads to producing the project charter document. The project charter authorizes the project and fully activates the environment to start operating on the project. As the project environment does influence—and as a result both positively and negatively impacts—the project, you must implement project management accordingly to lead the project to success. As illustrated in Figure 2-1, the main elements that constitute the project environment are enterprise environment factors, organizational assets, and project stakeholders.

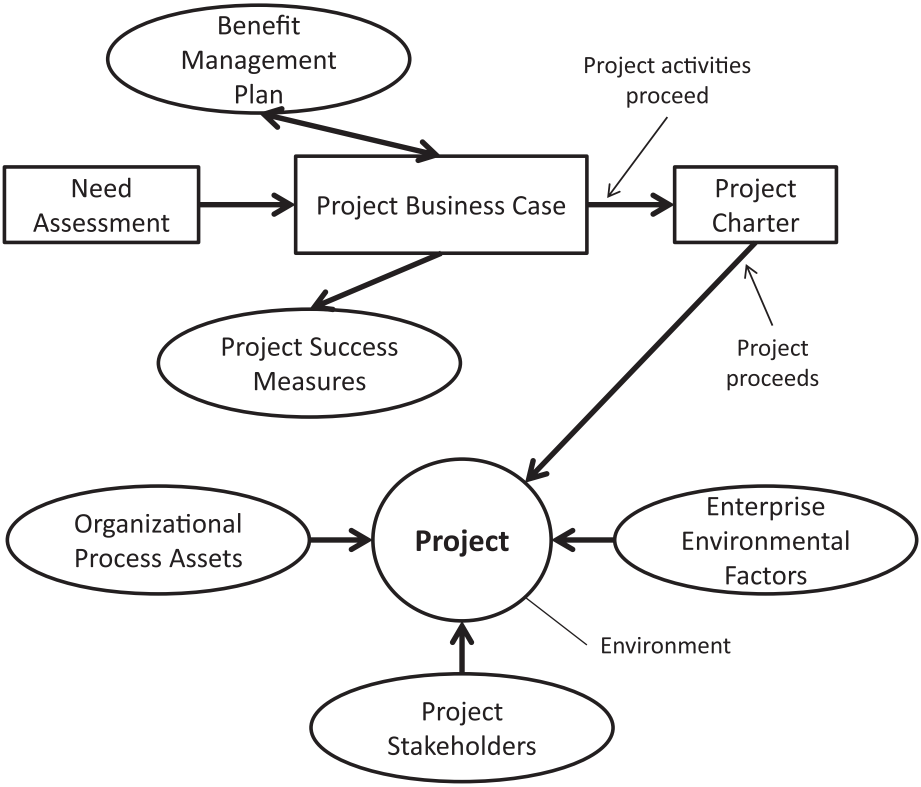

Figure 2-1. The big picture of the project environment: organizational structure, enterprise environment factors, organizational assets, and project stakeholders contribute to environment that influences a project

Enterprise Environment Factors (EEF). Enterprise environmental factors are factors that are related to the environment either internal or external to the performing organization and that can influence and potentially impact the project. Some examples are the organization's structure and culture and any city culture conditions external to the organization. The EEF are external to the project.

Organizational Project Assets (OPA). These are the processes or process-related assets of the project-performing organization that can be used to help the project succeed. Procedures, templates, and lessons-learned databases developed from previous projects are some examples. The OPA are internal to the organization and external to the project.

Project Stakeholders. Stakeholders can be both internal and external to the organization and the project. The project team and project sponsor in the organization are examples of internal stakeholders, and customers the external.

Note that, understandably, the project environment is largely created by the performing organization. For presentation convenience, we will start with EEF and OPA. Let's explore the enterprise environmental factors along with the organizational process assets in some detail.

Identifying Environmental Factors and Process Assets and Their Influence on Process

While exploring the general environment of the performing organization, you should identify the environmental factors and the process assets that will influence your project. Some of these factors and assets can be used to help the project; others may have a negative influence. However, in either case, you need to manage them.

Enterprise Environmental Factors

Enterprise environmental factors are the factors that are related to the environment either internal or external to the performing organization and that can potentially influence and hence impact the project. They may originate from within the performing organization, from outside of organization, or from both. These factors may have a positive or negative influence on the project; e.g.; some factors may facilitate the project and some others may give rise to constraints. Some types of examples of organizational environmental factors are presented in Table 2-1.

Table 2-1. Some Examples of the Organizational Environmental Factor Types

EEF Type	Examples	Internal/External
Organization structure, governance, and culture	Vision, mission, values, beliefs, leadership style, management style, code of conduct, cultural norms	Internal
Infrastructure	Facilities and equipment to do the project, telecommuting support, computer hardware to run communication software and other project-related applications	Internal
Information technology software	Project management information systems such as software tools for scheduling tasks and meetings	Internal
Employee capability	Competencies, human resource department, relevant skills and specialty knowledge	Internal
Resource availability	Constraints on contracting and purchasing, approved list of procurement providers, work authorization system	Internal
Geographic distribution of facilities and resources	Work location, collaboration software, video conferencing tools, distributed computing software like cloud computing	Internal
Physical environmental factors	Weather, transportation, housing	External
Social and cultural factors	Political climate, religious and cultural traditions, ethics	External
Legal restrictions and requirements	Country or city laws related to safety and security regulations	External
Government or industry standards	Regulatory agency regulations about prodution and environment, product standards, quality standards	External
Commerial databases	Standardized cost-estimating data, risk databases, benchmarking data	External
Academic research	Industry studies, research publications	External
Marketplace conditions	Trademarks, brand recognition, market shares, information about competitors	External

Caution! When identifying internal and external factors, it is important to consider the context of the factor. For example, the culture of the city where the performing firm is located is an external environmental factor, while the firm's culture in an internal factor.

Identifying the environmental factors is only part of the job, as you must effectively use the positive factors to help the project and try to take action to minimize the effect of negative factors on the project. Note that environmental factors can be internal to the performing organization, such as the organization's culture, or external to the organization, such as market conditions. However, the organizational process assets are internal only.

Organizational Process Assets

These are the processes or process-related assets from the organization that can be used to help the project get going and succeed. The organizational process assets are typically grouped into two categories: processes and procedures for conducting work, and a corporate knowledge database for storing and retrieving information. For example, the performing organization might have its own guidelines, policies, and procedures whose effect on the project you must consider while developing the project charter and other project documents that will follow. Another example of an organization's process assets is the knowledge and learning acquired from previous projects. The following list contains some items from both categories: processes and procedures and the knowledge database.

Processes, Procedures, and Policies. This category includes processes, procedures, policies, and other guidelines and requirements. In the following, we present some types and examples:

- **Standardized Processes and Procedures.** Examples are organizational-level policies, such as health and safety policies, ethics policies, project management policies, and quality policies and procedures, such as quality checklists and auditing processes.
- **Standard Guidelines and Criteria.** Examples are as follows:
    - Project closure guidelines, project acceptance criteria, proposal evaluation criteria, performance measurement criteria, and so on
    - Guidelines and criteria for tailoring the standardized organizational processes for the purpose of the project
- **Templates.** Examples are templates to support some project management tasks, such as a list of standard risks to look for, project schedule network diagrams, and the work breakdown structure.

- **Requirements.** Examples are the following:
  - Communication requirements, hiring requirements, and safety and security requirements
  - Guidelines and requirements for project closure, such as final mandatory project audits and product acceptance criteria

You need to follow these guidelines and accommodate the requirements while working out the details of the project management processes that you will perform.

As is clear from the few examples presented here, you will be using these process assets throughout the project lifecycle. Accordingly, these will get more coverage in the upcoming chapters of the book.

Tip Processes and procedures come from outside of the project—e.g.; project management office (PMO) or some other office within the organization—and you can't update them; while knowledge databases also come from outside the project, but you can and should update—i.e., add to—them.

Knowledge Database Repository. This category includes databases that allow you to do two things: 1) retrieve information to use it for your project, and 2) store information from your project as it proceeds for this and future projects to use. Here are some items in this category:

- **Project Files.** The documents and other files produced in the project, such as the project charter and scope statement
- **Measurement Database.** An example is a database for the performance measurements.
- **Historical Information and Lessons Learned.** Archives of files from previous projects, including lessons learned from the projects
- **Issue and Defect Management.** A database that allows the managing of issues and defects, such as logging, controlling, and resolving an issue or defect. You can also find the status of the issue or the defect from this database.
- **Financial Database.** The financial information related to the project, such as budget, work hours, and cost overruns

- **Configuration Management Database.** Contains the change history: different versions and baselines for the company standards, policies, and archived project documents

STUDY CHECKPOINT 2.1

Q1. From the organization's perspective, what is the core difference between enterprise environmental factors and organizational process assets?

Q2. In the following table, match each item in the first column to items in the second column.

Factor and Asset Categories	Factor or Asset Examples
Internal factor	A. Company's email system
	B. Check list
External factor	C. City laws where company is
Processes and procedures	D. Configuration management system
	E. An approved external provider
Knowledge databases	F. Commercial Risk database
	G. Interest rate
	H. Configuration repository from past projects of the company.

In a nutshell, enterprise environmental factors and organizational process assets contribute to the project environment along with project stakeholders, and this environment influences and impacts the project. One very important internal EEF is the organizational culture and structure, which we will discuss in more detail.

Note Enterprise environmental factors and organizational process assets are common inputs to many project management processes. Sometimes they can also appear as an output from a process, such as archived documents and lessons learned.

Understanding the Organizational Culture and Its Influence on Projects

Each organization often develops its own unique culture that depends on many factors, such as the application area of the organization and the general management philosophy implemented in the organization. The organizational culture includes the following elements:

- **Work Environment.** The organizational culture reflects work ethics and work hours. For example, do the employees work strictly from 8:00 a.m. to 5:00 p.m., or do they work late into the night and on weekends, or are employees are allowed to work from home?
- **Management Style.** The organizational culture also reflects authority relationships. Do the managers manage by authority or by leadership? How much feedback is taken from the employees in making management decisions? How do the employees view the authority of the management?
- **Policies.** The organizational policies, methods, and procedures also reflect the organizational culture.
- **Values and Vision.** A significant part of organizational culture lives in the set of values, norms, beliefs, and expectations shared within the organization. This may be impacted by the organization's mission and vision. For example, a nonprofit organization will have different values than a for-profit organization. Furthermore, one organization may encourage an entrepreneurial approach, while another organization may be rigidly hierarchical and may take an authoritarian approach in making decisions on what to do and what not to do.

Organizational culture has an influence on multiple aspects of a project, including the following:

- **Project Selection.** The organizational culture will creep into the selection criteria for projects and programs. For example, a rigidly hierarchical and authoritarian organization may not be very interested in programs and projects with high risk.
- **Project Management Style.** The project manager should adapt the management style to the organizational culture. For example, an authoritarian style may run into problems in an entrepreneurial organization with a participative culture.

- **Team Performance Assessments.** While making team performance assessments, the project manager should keep in mind the established norms and expectations within the organization.
- **Project Policies and Procedures.** The project policies and procedures will be influenced by the organizational policies and procedures because both should be consistent with each other.

While itself a contribution to the organizational system, the culture of an organization is greatly influenced by its structure.

Understanding the Organizational Structures and Their Influence on Projects

From the perspective of a project, organizational structures can be divided into three groups: project friendly, not project friendly, and a spectrum of types in between. Project-friendly organizations are project-oriented organizations, and those with PMO have high project resource availability and employ full-time project managers with almost full authority. On the contrary, non–project friendly organizations, such as functional—also called centralized—organizations have little to no project resource availability and only hire part-time project managers with little to no authority. Project-friendly organizations may be further grouped into two subcategories—those that derive their revenue primarily from performing projects for others and those that do in-house projects to deliver products or services for customers.

Project-friendly organizations are well aware of the importance of project management and generally have systems available to support project management. Non–project friendly organizations generally have a low appreciation for and understanding of the importance of project management and often lack systems to support project management. By *systems*, I mean tools and facilities specialized or suitable for performing project management effectively, such as project management information systems.

Caution! In the case of project resources, the key word here is *availability*: in-house, easily accessible online, or in any other form.

To do your job efficiently and effectively, you must figure out what kind of organizational structure you are working in. An effective project manager understands the organizational structure and leverages it for the success of the project. The exact structure of any organization results from an interplay

of a multitude of variables and is unique. However, here, in the context of a project, we will discuss a few organization types as defined by their structures: functional organizations, project-oriented organizations, matrix organizations, and more.

Functional Organizations

A functional organization has a traditional organizational structure in which each functional department, such as engineering, marketing, and sales, is a separate entity. A typical functional structure is shown in Figure 2-2, where each member (staff) of each department reports to the functional manager of that department, and the functional manager in turn reports to an executive, such as the chief executive officer (CEO). Depending on the size of the organization, there could be a hierarchy within the functional managers—for example, directors of engineering, QA, and IT operations reporting to the vice president (VP) of engineering, who in turn reports to the CEO.

The scope of a project in a functional organization is usually limited to the boundaries of the functional department. Therefore, each department runs its projects largely independent of other departments. When communication needs to occur between two departments, it is carried out through the hierarchy of functional managers.

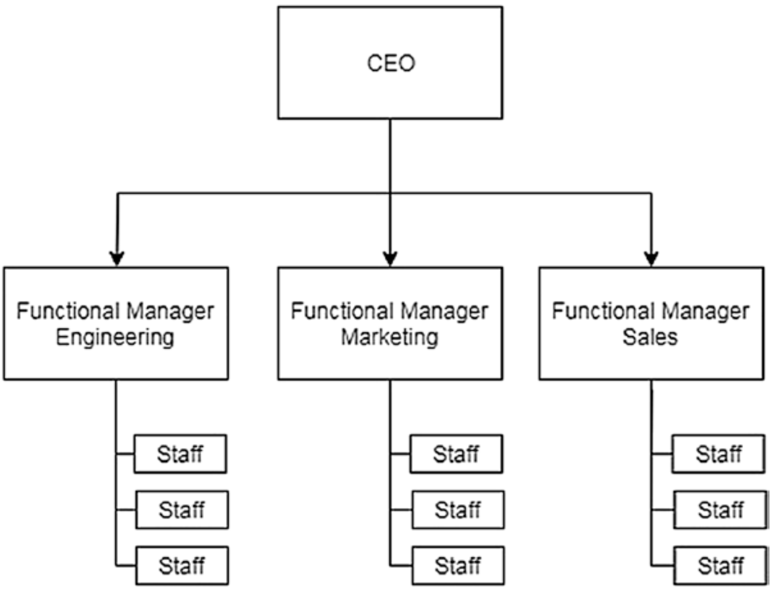

Figure 2-2. A simple example of the structure of a functional organization

All the managerial power, or authority, in a functional organization is vested in the functional managers, who generally control the team members' performance evaluations, salary, bonuses, hiring, and firing. With their role limited to coordinating the project activities, project managers are held responsible for the project results even though they have little say in resource assignments and holding team members accountable for their work. As a result, being project manager in a functional organization can be challenging and sometimes frustrating. You, as a project manager in a functional organization, can benefit greatly from your good relationships with functional managers and team members. Networking and leadership are the keys to your success in a functional organization.

A project manager in a functional organization has the following attributes:

- The project manager's role and the project team are part-time
- There is little or no authority over anything: resource assignments, team members, and the like.
- The project manager reports directly to a functional manager.
- There is little or no administrative staff to help project manager with the project.
- Little or no project resources are available.

Note In functional organizations, project management might be conducted under other names, such as project coordinator or team leader.

On the other end of the spectrum is the project-oriented organization.

Project-oriented Organizations

A project-oriented organization's structure is largely organized around projects. Most of the organization's resources are devoted to projects. An ideal simple structure example for project-oriented organizations is shown in Figure 2-3, where project team members report directly to the project manager, who has a great deal of independence and authority. Along with responsibility comes a high level of autonomy over the projects. The project managers are happy campers in a projectized organization. Functional organizations and project-oriented organizations are on opposite ends of the spectrum as far as a project manager's authority and project resource availability.

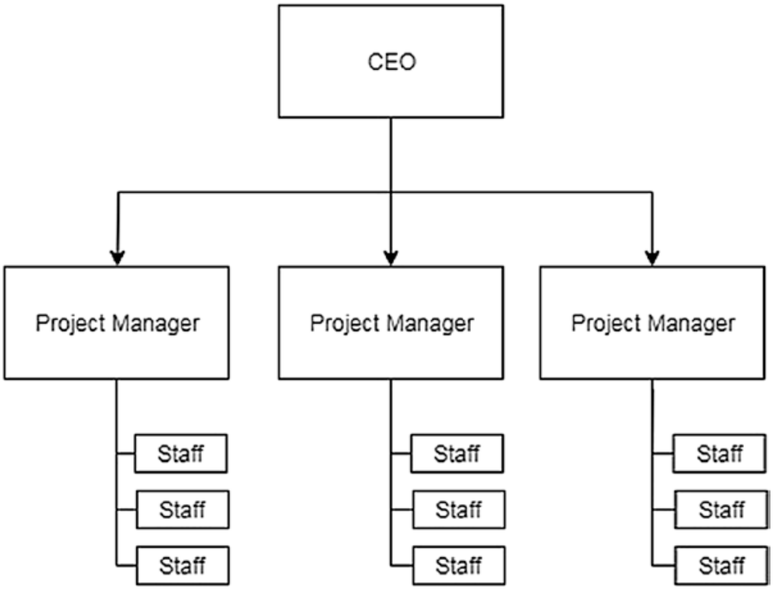

Figure 2-3. A simple example of the structure of a projectized organization

A project manager in a projectized organization has the following attributes:

- The project manager is fulltime.
- The project manager has full authority over the project team.
- There is fulltime administrative staff to help with the project.

A project management office (PMO) is another organizational structure, discussed at the end of this section, in which project managers are fulltime with high authority and a high availability of project resources.

On the scale of project friendliness, next to project-oriented organizations and PMOs are matrix organizations.

Matrix Organizations

A matrix organization is organized into functional departments, but a project is run by a team that may have members coming from different functional departments. As shown in a simple example in Figure 2-4, the project would be managed by a project manager belonging to the functional department of project management. Of course, project team members would come from other departments. On the spectrum of a project manager's authority, full- or

part-time employment, and project resource availability, matrix organizations come in next to project-oriented organizations and PMOs. Matrix organizations are generally categorized into a strong matrix, which is closer to project-oriented structure; a weak matrix, which is closer to a functional structure; and a balanced matrix, which is in the middle of strong and weak.

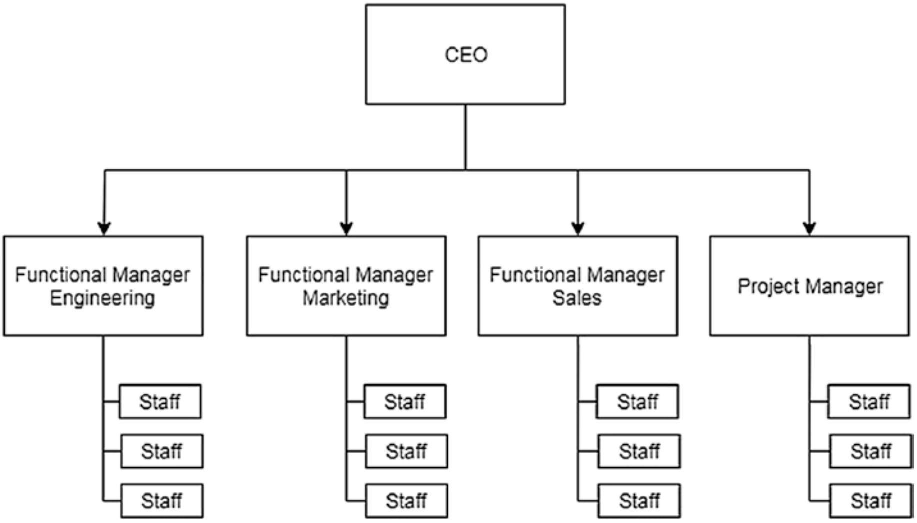

Figure 2-4. A simple example of the structure of a matrix organization

We have explored three of the main organizational structures. In the real world, some organizations use a hybrid (mix) of these structures to meet their varied needs. For example, a functional organization may run a specific project just like it would be run in a projectized organization. Such organizations are called, well, hybrid organizations.

Hybrid Organizations

A hybrid organization is a type of organization that contains elements of multiple other organizational structures, such as functional, matrix, and projectized. For example, consider an organization that has a traditional functional departmental structure, but launches some projects within a single department, and some interdepartmentally; some of the project managers are fulltime, some part-time, with varying authority. So, what you've got here is a hybrid organization.

Tables 2-2 and 2-3 summarize the influences of the different organizational structures on projects.

Table 2-2. Influences of the Organizational Structures on Projects

Organization Structure				
Project Characteristic	**Functional**	**Project-oriented**	**PMO**	**Hybrid**
Group arranged by	Job function	Project	Mixed	
Project manager's authority	None to little	High to almost full	High to almost full	Mixed
Project manager's role	Part-time	Part-time to fulltime	Fulltime	Mixed
Project management administrative staff	Part-time	Part-time to fulltime	Fulltime	Mixed
Project budget controlled by	Functional manager	Project manager	Project manager	Mixed
Resource availability	None to little	High to almost full	High to almost full	Mixed

Note In a weak matrix, the role of a project manager is more of a coordinator or an expediter like in functional organizations, and in a strong matrix, the project manager may have considerable authority close to that in a project-oriented organization.

Table 2-3. Influences of the Matrix Organizational Structures on Projects

Type of Matrix Structure			
Project Characteristic	**Weak**	**Balanced**	**Strong**
Work groups arranged by	Job function	Job function	Job function
Project manager's authority	Low	Low to moderate	Moderate to high
Project manager's role	Part-time	Part-time	Fulltime
Project management administrative staff	Part-time	Part-time	Fulltime
Project budget controlled by	Functional manager	Functional manager, project manager, or both	Project manager
Resource availability	Low	Low to moderate	Moderate to high

Multi-Divisional, Organic, and Virtual Organizations

These are three more organizational structures whose influence we will discuss in the following.

Multi-Divisional. In this kind of structure, work groups or divisions are organized by product, production processes, portfolio, program, geographic region, or customer type. Each division functions like a department in a functional organization; the influence of this struture on the project is identical to that in a functional organization: parttime project manager with no or little authority and no or little project resource availability, etc.

Organic. In this flexible organization structure, also called simple or flat, there are minimal boundaries. For example, start-up companies often have this kind of structure. In this structure there are parttime project managers with no or little authority and no or little project resource availability. The projects are started by functional managers with parttime project management administrative staff.

Virtual. Welcome to the Information Age, and and thanks to the Internet or web technologies, we now have all kinds of virtual organizations and virtual projects in action. In this structure, where individuals and groups are connected through the web, we have fulltime or part-time project managers with low to moderate authority and low to moderate project resource availability. The projects may be started by functional managers or project managers with fulltime or part-time project management administrative staff.

Project Management Office (PMO)

The project management office (PMO) refers to an entity in an organization that is responsible for providing centralized support, control, or directives for projects in the organization. The actual structure and function of a PMO depends on the organization's needs.

The *supportive* PMO type provides templates and information about access, best practices, lessons learned from past projects, and training. In this type of structure, PMOs have a low degree of control and influence over the project.

On the control and influence scale, the next PMO type is the *controlling* type, where in addition to providing support, it requires compliance, including the following:

1. Use of specific templates, forms, and tools
2. Adoption of project management frameworks or methodologies
3. Conformance to a given governance framework

This type provides PMOs with moderate control over projects.

The maximum control and influence over projects is exercised by PMOs of the *directive* type, where they directly manage projects with full control.

As a PMO has a higher-level view of and data from all projects, it can help align the project objectives with the organization's strategy and in this way deliver added business value for the organization. A PMO can provide a measurement system at the organization level by integrating project data with the information from the organization strategy, and in this way act as a liaison between portfolio, programs, and project.

As already discussed in this chapter, organizational structure at least partially determines or reflects the management structure, governance structure, and culture of the organization. Organizational structure, governance structure, management structure, and culture are very significant factors in composing the organizational system; they have tremendous influence over projects. They are very important components of enterprise environmental factors.

In addition to enterprise environmental factors and organizational process assets, project stakeholders have tremendous influence—hence, impact—on projects.

So, who are project stakeholders? Let's meet them.

Introducing the Project Stakeholders

Right from the day you assume responsibility for managing a project, you start meeting a very special class of people called the *project stakeholders*. It is very important for the success of the project that you identify these individuals and communicate with them effectively throughout the project.

Identifying Project Stakeholders

Project stakeholders are individuals and organizations whose interests are affected (positively or negatively) by the project execution and completion. As they say in physics, action and reaction are equal and opposite; if a project is going to influence and hence impact stakeholders, they are going to impact the project back. If we consider, for simplicity, only two cases: a project stakeholder has something to gain from the project or something to lose to the project. Accordingly, these stakeholders fall into two categories—positive stakeholders, who will normally benefit from the success of the project, and negative stakeholders, who will see some kind of disadvantage coming from the project. The implications obviously are that the positive stakeholders would like to see the project succeed, and the negative stakeholders' interests would be better served if the project were delayed or canceled altogether. For

example, your city mayor might be a positive stakeholder in a project to open a Walmart store in your neighborhood because it brings business to the city, whereas some local business leaders might look at it as a threat to the local businesses and thereby may act as negative stakeholders.

Caution! Stakeholders can be grouped into more than two categories, as we will do in a separate chapter, but here for the sake of simplicity we broadly divide them into two groups: positive and negative.

Negative stakeholders are often overlooked by the project manager and the project team, which increases project risk. Ignoring positive or negative project stakeholders will have a damaging impact on the project. Therefore, it's important that you, the project manager, start identifying the project stakeholders early on in the project. The different project stakeholders can have different and conflicting expectations, which you need to analyze and manage. We will explore that and much more about stakeholders in the upcoming chapters. But for now, while noting that identifying all the project stakeholders might be a difficult task, let's meet some obvious stakeholders:

- **Project Management Office (PMO).** If your organization has a PMO and it is directly or indirectly involved in the project, then the PMO is a stakeholder in that project.
- **Project Team.** Project team broadly includes project management team and individuals who perform the work of the project to produce the project outcome. This team may consist of individuals from different groups and departments with different subject-matter expertise and skills.
- **Program Manager.** If your project is part of a program, then the program manager is certainly a stakeholder in your project.
- **Portfolio Managers and Portfolio Review Board.** A portfolio manager is an individual who performs high-level management or governance of a set of projects and programs and interfaces between the projects/programs and the business strategy of the organization for which the projects and programs are being run. The portfolio review board is a committee that selects and rejects projects by reviewing them for factors such as the project value, return on investment, and risks involved in performing the project.

- **Functional Managers.** These are individuals who play management roles within administrative or functional areas of the organization. For example, the VP of marketing is a functional manager and so is the director of engineering. The level of authority depends on their position in the hierarchy and also the organizational structure. For example, if you are using resources that are under a functional manager, that functional manager is a stakeholder in your project.
- **Operational Management.** These are the individuals who are performing management roles in the operational areas of the organization. For example, the director of IT, who is responsible for maintaining the computer network that your team is using, is a stakeholder in your project. Depending on your project, you might be handing over the product of the project to an operations group that will be responsible for providing long-term support for it.
- **Sellers and Business Partners.** Business partners are entities external to the performing organization, such as contractors and suppliers that enter into a contractual agreement with the performing organization to provide certain components for the project. These components are the products, services, or results that you procure. Business partners are the external organizations that fill a specific role for the project, such as installing the product of the project, providing training and support for the product, or providing specialized expertise for the project. Business partners are different from vendors in that they have a special ongoing relationship with the organization, which often is attained by satisfying some requirements, such as a certification.
- **Customer/User.** In general, customers are the entities that will acquire the project's outcome, such as a product, and users are the entities that will use the product. In some cases, customers and users may be the same entity, and in other cases there may be a whole chain (with different layers) of customers and users. For example, a textbook produced by a project run by a publisher is recommended by instructors, bought by bookstores, and used by students.

- **Project Sponsor.** This is the individual or group that provides financial resources for the project. A sponsor has a major stake in the project and may play an active role in the project team from time to time. The following are some of the functions of a sponsor:
    - The sponsor champions the project when it's conceived. This includes gathering support for the project by performing actions such as acting as the project spokesperson to higher-level management and by spelling out the benefits of the project.
    - The sponsor leads the project through the selection process until the project is finally authorized, at which point the leadership role goes to the project manager.
    - The sponsor plays an important role in developing the initial project scope and charter.
    - The sponsor serves as an authority and a catalyst for issues beyond the control of project managers, such as authorizing some critical changes and other yes/no decisions.

In addition to these key stakeholders, who are easy to identify, there can be a number of other stakeholders who might be more difficult to identify both inside and outside your organization. Depending upon the project, these might include investors, sellers, contractors, family members of the project team members, government agencies, media outlets, lobbying organizations, individual citizens, and society at large. Have I left anyone out?

While dealing with the stakeholders, the keyword is *influence*. Watch out for influencers who are not direct customers or users of the product or service that will come from the project, but who can influence the course of the project due to their positions in the customer organization or performing organization. The influence can be either positive or negative—that is, for or against the project.

Caution! Do not confuse the project management team with the project team. The project management team consists of individuals involved in the project management tasks. It is a subset of the project team, which includes members of the project management team and also other members, such as those who perform the actual work of the project.

So, the stakeholders not only are affected positively and negatively by the project, but the project can also be impacted positively or negatively by them. It is critical for the success of the project that you identify positive, negative, and other types of stakeholders early on in the project, understand and analyze their varying and conflicting expectations, and manage those expectations throughout the project. We will return to this topic further on in the book where a full chapter is devoted to stakeholder management.

Hold on; when we were identifying project stakeholders, did somebody say *project manager*?

Identifying the Stakeholder Within: Project Manager

Of course you, the project manager, are one very special project stakeholder with a crucial stake: the project success. The job role of a project manager is extremely challenging and thereby exciting. In general, the role of a project manager is to lead the project team to meet the project objectives aligned with the company's strategic objectives. Depending on the company, you may be involved even before the project initiation stage in project-defining and -justification activities in the context of the company's objectives.

Tip Depending on the nature of the project and the company's needs, the project manager's role may be tailored, just like the processes to be run in the project.

You fulfill your role by aligning project objectives with company objectives, showing the vision to the project team, coordinating various project activities through communication, and leading the team in delivering the product to meet project objectives. You work within what is called the project manager's area (or sphere, as PMI calls it) of influence, which includes the project team, offices and managers within the performing organization, supplies, end-users and customers, and other stakeholders. Depending on the organizational structure of your organization, you may be interacting with a PMO, project sponsor, functional managers, program manager, portfolio manager, and possibly executives. Here, networking, formal and informal relation building, and communication skills are critical.

The importance of communication in project management cannot be overemphasized. Even a well-scheduled and well-funded project can fail in the hands of a hardworking team of experts due to the lack of proper communication. As a project manager, you might be dealing with a wide functional variety of individuals, ranging from executives to marketing personnel to technologists. You should be able to wear different communication hats depending upon whom you are communicating with. For example, you will not

be using unnecessary technical jargon to talk to executives or marketing folks, and you will not speak marketing lingo to the software developers. You will be speaking to different stakeholders in their language, while filling the language gap between different functional groups, and in that way you will eliminate misunderstandings resulting from miscommunication. The key point is that you put on the appropriate communication hat depending on which individual or group you are communicating with. Be able to switch communication hats quickly and avoid technical jargon and acronyms that are not understood by the person or group with whom you are communicating. The goal is clarity of language to convey the message accurately and effectively.

You will be communicating throughout the project. So, for a given project, you must develop a communication strategy that addresses the following issues:

- What needs to be communicated?
- With whom do you want to communicate? You might need to communicate different items to different individuals or groups.
- How do you want to communicate—that is, what is the medium of communication? Again, this might differ depending on whom you are communicating with.
- What is the expected and real outcome of your communication? You need to monitor your communication and its results to see what works and what does not so you can learn and improve.

Communication is also an ingredient for many other skills, such as negotiation and problem solving. We have two complete knowledge areas concerning this in project management, one for communication management and one for stakeholder management, and we will be covering them in upcoming chapters. But, from the discussion so far in this and previous sections, it is clear that it takes more than just knowledge of project management to be an effective project manager. Even in the very definition of project manager there appears the phrase "lead the project team." So, leadership skills are obviously necessary. PMI defines the project manager competencies by what it calls the PMI talent triangle.

From the material covered so far in this book, you know project managers should 1) know project management, obviously; 2) lead the project team; and 3) align the project objectives with the organization's strategic and business objectives. The corresponding competencies or talents may be termed as 1) technical project management skills; 2) leadership skills; and 3) strategic and business management skills, respectively. Well, we have just defined the PMI talent triangle, shown in Figure 2-5 and further discussed next.

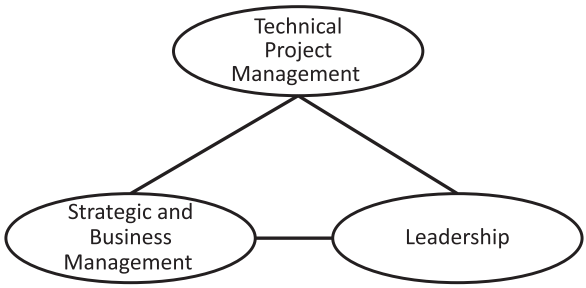

Figure 2-5. PMI Talent Triangle: combination of 1) technical project management skills; 2) leadership skills; and 3) strategic and business management skills

Technical Project Management Skills

In general, technical skills refer to the knowledge and ability to perform specific tasks in a specific field. The key word here is *practical* or *hands on* as opposed to just theoretical knowledge only. Technical tasks are usually performed in the field, such as mechanics, IT, and mathematics and science. As project management includes almost any field including these as its application areas, project management is also considered a technical field.

The technical project management skill, in general, refers to the ability to effectively apply project management knowledge to deliver the planned project objectives. Some top technical project management skills are discussed here:

1. **Manage Project Elements.** These skills refer to the general ability to effectively manage different project components, such as cost, resources, risks, and schedule.
2. **Plan and Prioritize.** These are the skills needed to plan thoroughly and prioritize things in the context of project objectives and stakeholder needs.
3. **Tailoring.** This is the ability to tailor tools, techniques, and methods according to the needs of the project at hand.
4. **Focus on Critical Elements.** These skills refer to the ability to focus on the critical elements of each project: critical success factors, schedule, some selected most-relevant financial reports, and issue log.

Strategic and Business Management Skills

Strategic and business management skills refer to having a high-level view of the company, with an understanding of its strategic and business objectives, and the ability to effectively use this understanding to perform certain tasks. These tasks include negotiating, implementing decisions, and performing other tasks, all with one goal in mind: the alignment of project outcome with the company's strategic objectives. You are not expected to be a business expert, but the more you know, the better it would be. Furthermore, you can get help from business experts in the company, including operation managers. You should have at least enough business knowledge to perform at the three levels of a task: organization level, project level, and alignment level.

Organization Level. These strategic and business management skills refer to the ability to know and explain the organization's mission, strategy, goals and objectives, and product and services. You should also know and be able to explain the following:

1. What are the market conditions of the business the company is in? How big is the market, and is it expanding or going downhill? Who are the customers? What would be the right time to market the project's product? And so forth.
2. What are the different aspects of the company's business operation, such as type of operation, technology being used, and so on.
3. What are competitor companies and what is their position in the market?

Project Level. These strategic and business management skills refer to knowing and being able to explain the project being managed. Moreover, with help from the project sponsor and business experts, you, working with the project team, should be able to develop the project delivery strategy in light of the organization's strategy. Once the project strategy is in hand, you should be able to implement it in such a way that the project adds maximum business value to the organization.

Alignment Level. These skills refer to the ability to align the project objectives and deliverables with the organization's strategy. This is another way of saying what we said in the previous paragraph: you will implement the project strategy to add maximum business value to the organization. In practice, it's done by setting your priorities correctly and being tactical in order to deliver the project outcome in light of the organization's strategy.

In a nutshell, strategic and business management skills are the abilities to understand organization strategy, draw a project-delivery strategy from it, and align the project strategy with the organization's strategy, as illustrated in Figure 2-6.

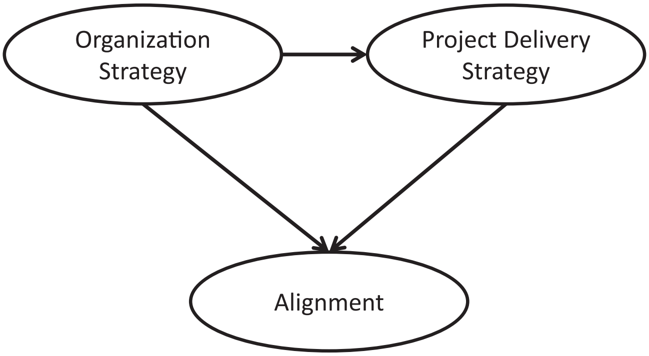

Figure 2-6. Strategic and business management skills: understand organization's strategy, draw project-delivery strategy from it, and align project strategy with organization's strategy

Leadership Skills

In a traditional organizational structure, such as a functional structure, project managers do not have formal authority over the project team members who perform the team's work. So, you have no other choice than to manage by leadership and not by authority or power. The good news is that managing by leadership is overall more effective and productive than managing by authority anyway. A project team is generally a group of individuals coming together for the lifetime of the project, possibly from different functional groups and likely with different skills and experience. They need a leader to show them the vision and to excite, inspire, motivate, guide, and direct them toward the goals and objectives of the project. You, the project manager, are that leader, no matter what the organization's structure.

Leadership includes a plethora of capabilities or skills that you learn and develop by practicing them; e.g.; communication, negotiation, critical thinking, problem solving, and interpersonal. Interpersonal skills are very important because you practice leadership by dealing with people—in project management mostly

with project stakeholders. When dealing with people, the following are some of the qualities that good leaders generally exhibit:

Visionary. Visualize the product and how it fits into the big picture of the organization's strategy, and be able to translate this vision for the team. Have a holistic big-picture view of the project, accounting for all internal and external factors.

Team Builder. The ability to build an effective team using a fun attitude, a sense of humor, a positive and optimistic approach, and other appropriate personality traits.

Positive and Optimistic. While being aware of weaknesses and the negative side of things and working to correct them is good, always exhibit a positive and optimistic attitude when dealing with people.

Social Personality Traits. Be respectful; kind, courteous, and friendly; honest and trustworthy; and ethical in dealing with people. Show respect or sensitivity to other cultures, lifestyles, and ways of thinking.

Collaborative and Conflict Resolver. Adopt a collaborative, as opposed to confrontational, approach in dealing with people, managing relationships, and resolving conflicts.

Effective Communicator. Listening and showing interest by asking questions, giving and accepting feedback, and managing expectations are some of the important components of communication exhibited by a good leader.

Pro-integrity. Exhibit professionalism with integrity; give credit where it belongs.

Hands-on Skills. Critical and analytical thinker; problem solver; action and results oriented.

Tip Research shows the project managers, on average, spend 90 percent of their time on the job communicating.

Some of the skills mentioned or discussed here, such as communication, team building, and conflict resolution, will be further elaborated later in the book. However, negotiation, influencing, and problem-solving skills warrant more discussion here.

Three Skills: Negotiation, Influencing, and Problem Solving

Three skills, which are implicit parts of the PMI talent triangle, are worth an explicit discussion: negotiation, problem solving, and influencing.

Negotiation. A negotiation is give and take, with the goal of generating a win–win outcome for both parties whenever possible. For example, you might need to negotiate at any stage of the project lifecycle. Here are some examples of negotiations:

- Negotiating with stakeholders regarding expectations during project planning. For example, the suggested deadline for the project schedule might not be practical, or you might need a certain type or quantity of resources to make it happen.
- Negotiating with functional managers to obtain human resources, such as software developers and big-data experts
- Negotiating with team members regarding specific job assignments and possibly doing conflict resolution among the team members
- Negotiating changes to the project schedule, budget, or both because a stakeholder proposed changes to the project objectives
- Negotiating with external vendors in procurement. However, in contract negotiations, representatives from the legal department might be involved.

The ability to influence helps negotiations.

Influencing. *Influencing* means getting individuals or groups to do what you want them to do without necessarily having the formal authority to mandate an outcome from them. This is becoming an increasingly essential management skill in today's information economy. To exercise influence, you must understand both the formal and the informal structures of your organization. Again, you might need to use influence when you are dealing with any aspect of the project—for example, controlling changes to the project, negotiating schedule or resource assignments, resolving conflicts, and the like.

Sometimes you will be negotiating to solve a problem.

Problem Solving. Project-related problems might occur among stakeholders (including team members) or with projects. Either way, they are there to damage the project. Your task is twofold—identify the problem early enough and solve it. In doing this, you will be using critical thinking with both logical and quantitative approaches. Here is the general technique for accomplishing this:

1. **Identify the Problem.** Look for early warning signs by paying close attention to the formal progress reports and to what the team members say and do regarding the project. Once you identify a potential problem, do your homework. Understand and identify the problem clearly by collecting more information without passing judgment.
2. **Identify the Root Cause.** Analyze the information about the problem to discover its root cause or causes.
3. **Generate Possible Solutions.** Once the root cause or causes are clearly identified, work with the appropriate stakeholders, such as project team members, to explore multiple (alternative) solutions.
4. **Evaluate.** Assess the multiple solutions and choose the best one to implement.
5. **Implement.** Apply the chosen solution.
6. **Verify.** Assess and verify the effectiveness of the implemented solution.
7. **Repeat**. Depending on the results of verification, you may have to start again at any of the preceding steps.

The key point throughout the problem-solving process is to focus on the problem, not on the individuals, with the goal of finding a solution in order to help the project succeed. There should be no finger pointing.

As one of the three sides of the project manager's talent triangle, strategic and business management skills ensure that the project manager is able to participate in pre-initiation activities, such as defining the project—including its objectives and success criterion—and making a business case for the project, which leads to project selection.

Project Management Business Documents and Project Selection

In the previous chapter, we discussed how projects originate from their project initiation context; i.e., the need to

1. meet legal, regulatory, or social requirements;
2. satisfy stakeholder requests or needs;
3. implement or change business or technological strategies; or
4. create, improve, or fix products, processes, or services.

This context triggers the process of creating two project management business documents: 1) project business case, and 2) project benefit management plan.

Project Business Case

This document makes the case for the would-be project from a business perspective by providing necessary information that can be used to assess whether the expected project outcome is worth the required investment. It includes the business need, project objectives, and success criterion. The exact form and content may depend on the company, but the following standard components are usually there under some title names in this document.

Business Need. As previously mentioned, the creation process of the project business case document is trigged by some business need identified in the project initiation context. This document contains the summary of business assessment; in which state the business problem or opportunity is that is warranting action; what business value this action would add to the organization; what the scope of the effort is; and which stakeholders would be affected by this effort.

For example, think of a new technology that presents an opportunity for a company to expand its business.

Business needs present a situation that needs to be analyzed.

Business Analysis of the Situation. This analysis starts by identifying the origins of the business problem or opportunity at hand and the strategic objective and goals of the organization. Then, a gap analysis is performed by comparing project requirements with the present capabilities of the organization. The project risks and critical factors to consider in evaluating success are also laid out.

With all this information, the obvious question the document addresses is what to do about the problem or opportunity. It may propose different solutions and then propose the criterion by which to evaluate these different ways to help you make the decision—the decision criterion. For example, to address a problem, if it proposes the solutions A, B, and C. For each of A, B, and C, it answers the question: To address the problem, what is required to be done at a bare minimum? What is only desired but not required; and what is optional, or not essential? The answers to these questions will help you decide which path should be taken to respond to the problem or opportunity.

The business case also records the different ways to respond to the problem or opportunity.

Option: What to Do? These are different solutions or alternative ways to address the problem or opportunity. The very basic set of options a business case could address is as follows: do nothing, i.e., no project; do the minimum; or do more than the minimum. Then there would be alternative ways of doing.

Recommendation: What Path to Take? This component of the business case recommends one of the options considered in the document, citing the option analysis results. For the option, it also includes constraints, dependencies, and assumptions and risks along with the factors to be used to measure the project success. Furthermore, the milestones and roles and responsibilities of the project are laid out.

Evaluation: **How to Measure to Benefits?** This component describes the plan of how the benefits delivered by the project will be measured throughout the project lifecycle.

In summary, a business case presents and analyzes a problem or an opportunity in the context of the organization's strategy; proposes alternative courses of action and the criterion of how to select one out of these; based on this criterion, recommend one and state how to measure the benefits and success of the project that would come out of the recommended course of action.

Sounds like a lot to carry in one document, but remember that the business case is not a self-contained document. It depends upon or refers to other documents, such as business need assessment, project success measures, and project benefit management plan.

Tip A business case document is used to authorize further project management activities, and usually the project sponsor is responsible for its development and maintenance throughout the project lifecycle in case the project is finally approved.

Project Benefit Management Plan

The project benefit management plan document describes what, when, and how project benefits would be delivered, as well as how they would be measured. The key elements in the document answer some key questions, such as:

1. What are the project's **target benefits** and how well do they **align** with the organization's business strategy?
2. What is the **benefit delivery timeframe**; e.g.; short term, ongoing, phase-by-phase, or long term?
3. Who is the **benefit owner** to record, report, and monitor the benefits as they materialized?
4. What are the **metrics** to tag or mark the realization and measurement of each benefit?
5. What are the key **assumptions and risks** regarding the benefit realizations?

This document defines the target benefits of a given project. But, in general, a project benefit is any project outcome that delivers value to the organization or to the stakeholders who are the planned beneficiaries of the project. The information from *business need assessment* and *business case* documents is used in developing the project benefit management plan document.

Caution! The project manager must keep the general management approach in harmony with the theme of the *business case* and the *project benefit management plan* documents, which are interdependent and are developed iteratively and maintained through the project lifecycle.

In addition to project benefits, the business case document also refers to project success measures. In fact, all these documents and plans are being developed to gear the project toward success. So, what is project success, and how is it measured?

Project Success Measures

Before we can talk about measuring the project success, we need to define. Although most project practitioners and researchers agree that project success is defined and measured by the degree of meeting the project objectives. However, different stakeholders can have different ideas about which factors to count and with how much weight in measuring success; e.g.; time, cost, quality, alignment of result with organization's business strategy, etc.

The bottom line is that project success is defined and methods or metrics to measure it are determined for every project uniquely.

Obviously, the factors chosen to define success should be reliably measurable. For example, here are some financial factors that can be used to measure the success of a project:

- **Return on Investment (ROI).** The ROI is the percentage profit from the project.

  For example, if you spend $400,000 on the project, and the benefit for the first year is $500,000, then ROI equals ($500,000–$400,000)/$400,000, which equals 25 percent.

- **Benefit Cost Ratio (BCR).** This value is obtained by dividing the benefit by the cost.

  The greater the value, the more attractive the project is. For example, if the projected cost of producing a product is $20,000, and you expect to sell it for $60,000, then the BCR is equal to $60,000/$20,000, which is equal to 3. For the benefit to exceed the cost, the BCR must be greater than 1.

- **Present Value (PV) and Net Present Value (NPV).** To understand these two concepts, you must understand that one dollar today can buy you more than what one dollar next year will be able to buy. (Think about inflation and return.) The issue arises because it takes time to complete a project, and even when a project is completed, its benefits are reaped over a period of time, not immediately. In other words, the project is costing you today but will benefit you tomorrow. So, to make an accurate calculation for the profit, the cost and benefits must be converted to the same point in time. The NPV of a project is the present value of future cash inflows (benefits) minus the present value of current and future cash outflows (cost). For a project to be worthwhile economically, the NPV must be positive. As an example, assume you invest $300,000 today to build a house, which will be completed and sold after three years for $500,000. Also assume that real estate that is worth $400,000 today will be worth $500,000 after three years. So, the present value of the cash inflow on your house is $400,000, and hence the NPV is the present value of the cash inflow minus the present value of the cash outflow, which equals $400,000–$300,000, which equals $100,000.

- **Payback Period (PBP).** Payback period is defined as the duration of time required to recoup the original amount of investment. For example, a $15,000 investment made at the start of year 1 that returned $5,000 at the end of each year for first three years would have a three-year payback period. The longer the payback period, the less desirable the investment is. This is because, as explained earlier, the value of the money unit—e.g.; dollars—decreases with time.
- **Internal Return Rate (IRR).** This is just another way of interpreting the benefit from the project. It looks at the cost of the project as the capital investment and translates the profit into the interest rate over the life of that investment. Calculations for IRR are outside of the scope of this book. Just understand that the greater the value for IRR, the more beneficial the project is. Technically, IRR is defined as the interest rate at which the net present value of all the cash flows (both positive and negative) from a project or investment equal zero.

Now, what is cash flow?

- **Cash Flow (CF) and Discounted Cash Flow (DCF).** Whereas *cash* refers to money, *cash flow* refers to both the money coming in and the money going out of an organization. Positive cash flow means more money is coming in than is going out. Cash inflow is benefit (income), and cash outflow is cost (expenses). The discounted cash flow refers to the amount that someone is willing to pay today in anticipation of receiving the cash flow in the future. DCF is calculated by taking the amount that you anticipate to receive in the future and discounting (converting) it back to today on the time scale. This conversion factors in the interest rate and opportunity cost between now (when you are spending the cash) and the time when you will receive the cash back.
- Other examples of factors that may be used as success measures include other financial and non-financial project objectives; the business value added to the organization to change its state; and fulfilling the terms and condition of a contract. The key point is that for each project, before the rubber hits the road, the success must be defined, method and factors to measure it determined, and agreement among appropriate stakeholders reached.

Tip One of the most important technical aspects of project management is that you are able to measure items such as project benefits, project progress, and project success. So, for example, if your project is a 99 percent success, this success will not be a matter of opinion or perspective; rather, this success will be rock solid as it's measured.

Well, we started with need assessment, looked at project management business documents—i.e., business case and project benefit management plan—and now know how to measure project benefits and project success. With all this data and information, are we ready for project authorization? Not quite yet.

Project Authorization

Figure 2-7 illustrates the procedure of project authorization. As pointed out earlier, the business case document is used to authorize further project management activities. However, the project is formally authorized by the project charter document issued by the project sponsor, which allows the project manager to start using the organization's resources for the project. We will learn in the next chapter how to produce the project charter.

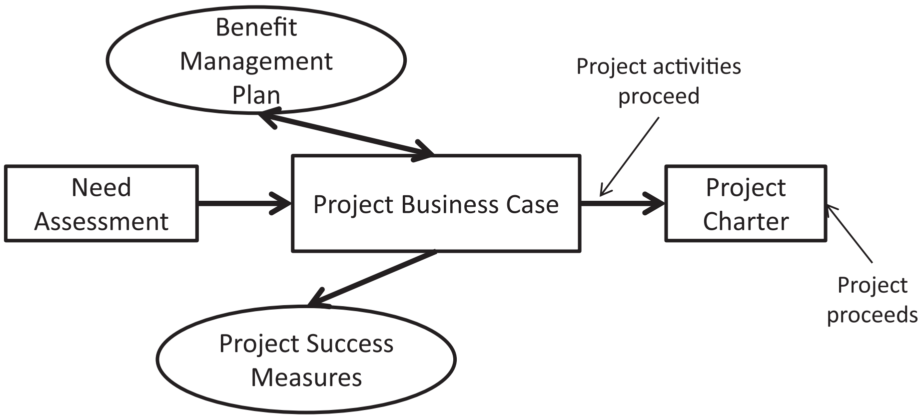

Figure 2-7. Project selection procedure: project management activities are authorized based on project business case document, and project is authorized based on project charter document

As part of the project selection procedure, various scoring or other models may be used to choose between different courses of action as a response to the problem or opportunity, as discussed in the "Project Business Case" section. Similarly, various economic models may be applied to assess the

project benefits; quantities or factors like return on investment and benefit cost ratio, discussed in the previous section, can be used. These models are out of the scope of this book.

Two other simple tools that can be used during the project selection procedure are opportunity cost and expert judgment.

Opportunity Cost

Opportunity cost refers to selecting a project over another due to the scarcity of resources. In other words, by spending this dollar on this project, you are passing on the opportunity to spend this dollar on another project. How big an opportunity are you missing? The smaller the opportunity cost, the better it is.

STUDY CHECKPOINT 2.2

You have been offered a Project B that will earn you a profit of $100,000 in three months. You already have an offer of a Project A that will earn you a profit of $70,000 in three months. You can only do one project during these three months, and the project requesters are unable to move the project durations.

Q1. What is the opportunity cost of Project A?

Q2. What is the opportunity cost of Project B?

Q3. Just based on the opportunity cost, which project will you select?

Q4. Describe what can change your decision based just on the opportunity cost.

Expert Judgment

Expert judgment is one of the techniques used in project management to accomplish various tasks; for example, it's used to perform various project management processes, as you will see in upcoming chapters. It may be used during the project selection procedure. It refers to relying on expert advice and using that advice as the only factor or one of multiple factors to make a decision. This expert advice can come from one or more of the following sources:

- Senior management
- An appropriate unit within the organization

- Project stakeholders, including customers and sponsors
- Consultants
- Professional and technical associations
- Industry groups
- Subject-matter experts from within or outside the performing organization
- The project management office (PMO)

As previously mentioned, the use of expert judgment is not limited to project selection; it can be used in many processes, such as developing a project charter. Expert judgment can be obtained by using a suitable method, such as individual consultation, interview, survey, or panel group discussion.

Caution! Keep in mind that expert judgment can be very subjective at times and might include political influence. An excellent salesperson or an executive with great influence can exploit this method successfully.

Summary

In an organization, a project is born out of the need to address a problem or an opportunity while staying in alignment with the organization's strategy. The project is born and performed in a certain environment constituted by three components: enterprise environmental factors (EEF), organizational process assets (OPA), and project stakeholders. EEFs are environmental factors, which can be internal to the organization, such as organizational structure and culture, or external to the organization, such as the law of the land where the organization is located. However, OPAs are only internal to the organization and of two types: processes, policy, and procedures; and knowledge database repositories. The project manager cannot change policy and procedures but can add to the knowledge databases. Enterprise environmental factors are related to how the performing organization does its business, whereas organizational process assets are specific to how the organization runs its projects.

Project environment influences and hence impacts the project. As a project is being influenced and impacted by its environment, it or its outcome influence and impact back some element of the environment. The goal of project management is to manage the influence of the environment on the project in such a way that the project influences back to change the business-value state of the organization to a higher level.

The organization's business need triggers the process of creating two project management business documents: 1) project business case, and 2) project benefit management plan. The project sponsor authorizes the project by signing the project charter, a document based on these two project management business documents. So, how do we prepare the project charter document?

Road Ahead. The project charter is produced in the initiating stage, the first of the five stages or process groups of the project lifecycle that we explored in Chapter 1. In the next chapter, you will learn the process of creating the project charter as well as the rest of the processes used to integrate the activities from all five project stages.

Exam's Eye View

Comprehend

- Project environment that influences projects largely constituted by enterprise environmental factors (EEF) and organizational project assets (OPA) in addition to project stakeholders.
- EEFs may be internal to the performing organization, such as organizational structure and culture, or external, such as marketing conditions and legal restrictions, while OPAs are internal only, such as policies and procedures, and knowledge database repositories.
- A project is run in an environment constituted by organizational structure, organizational culture, enterprise environmental factors, and organizational process assets.
- The project manager's authority is none to little in a functional organization, low to high in a matrix organization, and high to almost full in a project-oriented organization.
- To be an effective project manager, it takes more than just the knowledge of project management; it requires the PMI talent triangle: 1) technical project management skills, 2) leadership skills, and 3) strategic and business management skills.
- Strategic and business management skills are the abilities to understand the organization's strategy, draw a project delivery strategy from it, and align the project strategy with the organization's strategy.

Look Out

- The same item may have entry into different kinds of EEFs and OPAs; context is important. For example, the culture of a company is an internal EEF, while the culture of the country in which the company exists is an external EEF.
- You can update—i.e., add to—a knowledge repository; from the processes, policies, and procedures part of OPAs, you cannot update policies and procedures, but you can and will be updating some items, such as the project plan.
- Any individual or organization that is affected by a project and can influence, and hence impact, it is called a project stakeholder. Stakeholders certainly exist inside but can also exist outside of the performing organization.
- You must identify both types of stakeholders of your project, including positive and negative, and you must not ignore the negative stakeholders.
- Regardless of the structure of the performing organization, project managers are responsible for project results.
- The project charter is the only document that is issued to authorize the project, while the business case document is only used to authorize the project management activities to continue until the project is finally authorized or disapproved.

Memorize

- Between EEF and OPA, items related to processes, policies, procedures, and knowledge databases, including lessons learned and OPAs; the rest are EEFs
- The organizational structure table
- Knowledge, performance, and personal abilities are the three kinds of characteristics that are necessary for a project manager in order to effectively manage projects.
- In some organizational structures, such as functional organizations, project management might be conducted under other names, such as project coordinator or team leader.
- PMI talent triangle: combination of 1) technical project management skills, 2) leadership skills, and 3) strategic and business management skills
- The two project management business documents are 1) project business case and 2) project benefit management plan.
- A project is authorized by the project sponsor's issuing the project charter.

Review Questions

1. In which of the following organizational structures does the project manager have the greatest authority?

   A. Functional

   B. Project-oriented

   C. Matrix

   D. Virtual

2. In which of the following organizational structures does the project manager have the least authority?

   A. Functional

   B. Project-oriented

   C. Matrix

   D. Virtual

3. Check each that is the correct representation of the PMI talent triangle:

   A. Leadership skills, strategic and business management skills, and the IT part of project management skills

   B. Technical project management skills, leadership skills, and knowledge of business strategy of the organization

   C. Technical project management skills, leadership skills, and strategic and business management skills.

   D. Strategic and business management skills, technical project management skills, and knowledge of the IT part of the company's business

4. Strategic and business management skills include all *except*:

   A. Understanding organization's business strategy

   B. Ability to draw project delivery strategy from organization's business strategy

   C. Ability to align project strategy with organization's strategy

   D. Ability to tailor the tools, techniques, and methods to effectively implement organization's business strategy though the project

5. The project resource availability is at maximum in organizations with the following structure(s):

   A. PMO

   B. Hybrid

   C. Multi-divisional

   D. Organic

6. The project manager is responsible for achieving project objectives in an organization with the following structure(s):

   A. Project-oriented only

   B. Strong matrix and project-oriented only

   C. PMO and projectized only

   D. All structures

7. You have just joined an organization as a project manager and are studying the enterprise environmental factors of the organization to find out how you can leverage them for the success of your upcoming projects. Enterprise environmental factors may have what kind of influence on the projects?

   A. Positive only

   B. Negative only

   C. Positive or negative

   D. None

8. Technical project management skills include the abilities to: (Check all that apply)

   A. Manage IT-related aspects of project only

   B. Focus on the critical elements of each project, such as critical success factors and schedule

   C. Tailor tools, techniques, and methods to the needs of the project at hand

   D. Plan and prioritize.

9. Select the internal enterprise environmental factors:
   A. Code of conduct within the performing company
   B. Code of conduct that people in the city where the company is are expecting you to follow
   C. Standardized cost estimate data on the company computer system
   D. Project team members who are living in and working from foreign countries
10. Which of the following are the project management business documents?
    A. Project charter
    B. Project business case
    C. Project benefit management plan
    D. Business need analysis
11. Which document is issued to authorize a project?
    A. Project Business Case
    B. Project Benefit Management Plan
    C. Project Charter
    D. Both Project Charter and Project Business Case
12. Who authorizes the project?
    A. Functional manager of the department where project will be performed
    B. CEO of the organization
    C. Project sponsor
    D. Project sponsor and project manager

CHAPTER

3

Project Integration Management

The objectives covered in this chapter make up 9 percent of the CAPM exam, equivalent to about 12 questions. Study the whole chapter in detail.

It's enough to just remember the names of the inputs, tools and techniques, and outputs. You should know what is in a given input item that the given process uses and how it helps in generating the output, as well as what a given tool or technique does in a given process.

While studying this knowledge area pay attention to how tasks can be tailored to meet needs, and recognize an agile environment in action; for example, continual assessment generates change requests, which lead to changing plans, or adapting.

P. Sanghera, *CAPM® in Depth*, https://doi.org/10.1007/978-1-4842-3664-2_3

CAPM Exam Objectives

Project Integration Management:

1. Understand the seven project management processes in the project integration management knowledge area.
2. Identify the input, tools, techniques, and outputs defined in the seven processes in project integration management.
3. Understand the purpose of project integration management and the project manager's role within it.
4. Identify concepts and procedures related to project change management.
5. Identify tailoring consideration in project integration management and recognize key documents.
6. Identify methods for project integration and knowledge management.

As you learned in Chapter 1, a project is performed by using processes that belong to five process groups and ten knowledge areas. The activities and results of most of these processes need to be integrated to drive the project to a successful conclusion. This integration is facilitated through the processes in the integration management knowledge area. First, the project needs to be chartered and authorized, which is accomplished during project initiation using the Develop Project Charter process of integration management. After the project has been initiated, you need to develop a project management plan, which becomes the primary source of information for how the project will be planned, executed, monitored and controlled, and closed. After you have performed the project planning by using the process in the planning process group and having your efforts coordinated by the Develop Project Management Plan process in the integration management knowledge area, you need to manage the project execution by using the processes in the executing process group. The execution efforts are coordinated by using the following integration management processes: Direct and Manage Project Work and Manage Project Knowledge. Furthermore, the project needs to be monitored and controlled throughout its lifecycle. These efforts are coordinated and integrated by using the processes in integration management, namely Monitor and Control Project Work and Perform Integrated Change Control. Upon completion or cancellation, a project needs to be properly closed. The closing efforts are coordinated by the integration management process called Close Project or Phase.

So, the central question in this chapter is as follows: How are the day-to-day efforts in a project coordinated and integrated to complete the project? In search of an answer, we will explore coordination and integration in three fundamental underlying areas: launching, i.e., initiating and planning, the project; directing, managing, and controlling the project execution; and closing the project. In other words, this chapter will present the big picture of project management from a more practical perspective.

Integration Management: Big Picture

By now, we already know that most of project management is performed through processes. However, project management is not just a collection of processes that you run one after the other and then are done. These processes depend on each other—i.e., they are logically linked to each other by outputs and input—and many of them need to be iterated several times based on the need. This implies that we need to oversee or coordinate the processes that we run to perform the day-to-day project management. The integration management knowledge area offers processes to accomplish just that; in other words, to define, identify, coordinate, and integrate various activities and processes within each project management process group. For example, the Develop Project Management Plan process coordinates the efforts of all the processes in the planning process group and integrates the results into the project management plan. The tasks of the integration management knowledge area are accomplished by using the integration management processes shown in Table 3-1 along with their major outputs.

Table 3-1. The Processes of Integration Management and Their Major Outputs

Process Group	Integration Management Processes	Major Output
Initiating	Develop project charter	Project charter
Planning	Develop project management plan	Project management plan
Executing	Direct and manage project work	Deliverables, work performance data, and change requests
	Manage project knowledge	Lessons learned register
Monitoring and controlling	1. Monitor and control project work	1. Work performance reports, change requests
	2. Perform integrated change control	2. Approved change requests
Closing	Close project or phase	Final product transition

As Table 3-1 demonstrates, integration management contains processes from all five process groups. These processes interact among themselves in complex ways. Some of the interactions are shown in Figure 3-1 and described in the following list:

1. The Develop Project Charter process generates the project charter, which, along with output from other processes, becomes an input item to the Develop Project Management Plan process, which in turn generates the project management plan.

2. The project management plan becomes an input to all five other processes of integration management: Direct and Manage Project Work, Monitor and Control Project Work, Perform Integrated Change Control, Manage Project Knowledge, and Close Project or Phase.
3. The Direct and Manage Project Work process generates the work performance data, which becomes an input item to the Monitor and Control Project Work process, which in turn generates the change requests and performance reports, both of which are input to the Perform Integrated Change Control process.
4. The Perform Integrated Change Control processes all the change requests, including those from the Direct and Manage Project Work process, and generates the approved change requests, which become an input item back into Direct and Manage Project Work, whose output, the deliverables, are input to Manage Project Knowledge and Close Project or Phase after being accepted.
5. The Close Project or Phase process also takes the project charter, an output of the Develop Project Charter process, as an input.

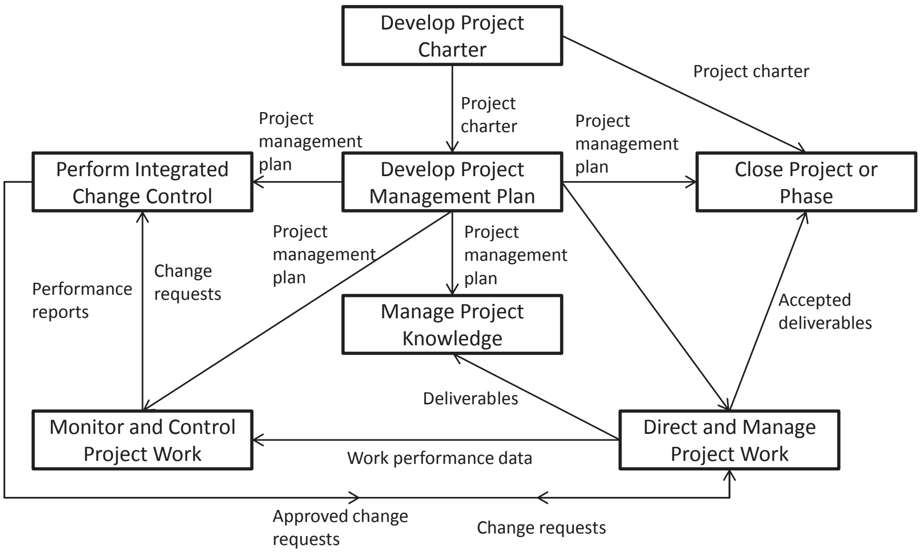

Figure 3-1. Big picture of interactions and data flow among different processes of integration management

So, integration management spans all the process groups: initiating, planning, executing, monitoring and controlling, and closing. To initiate a project, one must coordinate and integrate efforts to develop the project charter.

Note It is noteworthy that integration management is the only knowledge area to have processes in every process group; i.e., in all stages of the project lifecycle.

Developing the Project Charter

The project charter is a document that contains the high-level project information, such as the project's purpose, objectives, and preapproved financial resources. The single most important reason why this document is produced—using the Develop Project Charter process—is to receive the formal authorization for the project. To accomplish this, it is necessary that the charter clearly shows the business need for the project and that the project objectives align with the organization's strategic objectives. For this purpose, two project management business documents, the project business case and project benefit management plan, are produced as discussed in Chapter 2. Both of these documents are input to the Develop Project Charter process, as shown in Table 3-2, which also shows the other input items along with the tools and techniques applied on inputs to produce the listed outputs: the project charter and the assumptions log.

Table 3-2. The Develop Project Charter Process: Input, Tools and Techniques, and Output

Input	Tools and Techniques	Output
1. Business case	1. Expert judgment	1. Project charter
2. Benefit management plan	2. Data gathering	2. Assumptions log
3. Agreements	3. Meetings	
4. Enterprise environmental factors	4. Interpersonal and team skills	
5. Organizational process assets		

Note The project charter is the document that formally authorizes a project, and includes naming the project manager, determining the authority level of the project manager, and allowing the project manager to start using organizational resources on the project.

The other input items for the process of developing a project charter are discussed next.

Tip The business case document is developed from the project initiation context—i.e., the organization's business need—and is used to justify the investment in the project and to draw boundaries around the project; i.e., what is and is not included.

Agreements. When a project is to be performed for a customer who is external to the performing organization, it is usually done based on a contract. The contract may provide key information required for the charter, such as customer-side stakeholders and payment terms. However, in addition to a contract, an agreement may come in several other forms, such as verbal agreements, e-mail, letters of intent, service-level agreements (SLA), and memorandums of understanding (MOUs). We will explore the agreements further when we cover the procurement management knowledge area.

Enterprise Environmental Factors. During the development of the project charter, you must consider the performing organization's environmental factors relevant to this task, which include the following:

- **Government and industry standards**, such as legal requirements, product standards, and quality standards relevant to the project and used in determining the project requirements, etc.
- **Regulatory and legal requirements and constraints** can influence the product requirements.
- **Organization's culture and political climate** can influence how to process and channel the project charter and getting resources pre-approval.
- **Marketplace conditions** may influence milestone schedule and requirements.
- **Organizational structure and governance framework** may influence project manager's assigned responsibility and authority level and the decision on who will have authority on the project.
- **Stakeholders' expectations and their risk threshold** can influence several elements of the charter, such as product requirements, milestone schedule, overall project risk, project objectives, and success criteria.

Note that the environmental factors can be internal to the performing organization, such as the organization's culture, or external to the organization, such as market conditions.

Organizational Process Assets. As you learned in Chapter 2, the organizational process assets are typically grouped into two categories: processes and procedures for conducting work, and a corporate knowledge database for storing and retrieving information to help the project and its processes. For example, the performing organization might have its own guidelines, policies, and procedures, whose effect on the project must be considered while developing the project charter and other project documents that will follow. Another example of an organization's process assets are the knowledge and learning acquired from previous projects. Here are some specific examples of organizational process assets that can be useful in developing the project charter:

- Templates to support some project management tasks, such as project charter templates
- Standard policies and procedures of the organization relevant to developing the project charter
- Procedures for issuing work authorizations
- Knowledge database of the organization that contains historical information from previous projects, such as project selection decisions and project performance

To summarize, the input items to developing the project charter may include two business documents—project business case and project benefit management plan—enterprise environmental factors, organizational process assets, and possibly a contract or some other form of agreement. You take the available inputs and apply the relevant tools and techniques to develop the project charter.

Tools and Techniques to Develop Project Charter

Expert judgment, data gathering, meetings, and interpersonal and team skills are used as tools and techniques to develop the project charter, as described in the following.

Expert Judgment. Expert judgement as a tool is discussed in Chapter 2. To develop the project charter, expert judgement may be sought in the relevant area, such as organization strategy, to ensure the project aligns with this strategy, benefit management, duration estimation for milestone schedule, budget estimation, risk identification to assess high-level overall project risk, and the field of the project.

Data Gathering. To collect data in the process of developing the project charter, data-gathering techniques such as interviews, focus groups, and brainstorming can be used. Interviews can be conducted in a formal or informal setting to obtain information from experts or stakeholders on any

appropriate topic, such as stakeholder expectations, product requirements, project risk estimation, and project constraints. You can bring together an appropriate set of stakeholders and experts on any relevant topic, such as project success criteria and risk identification. This is a form of focus group. Furthermore, in the process of using this information to produce a project charter, you can use brainstorming if you get stuck or just to make sound decisions. The brainstorming technique is generally used in a group environment to gather ideas as candidates for a solution to a problem or issue without any immediate evaluation of these ideas. The evaluation and analysis of these ideas happens later.

Meetings. We have already motioned this tool. This is a very general tool and can be used when appropriate to collect or discuss information on any topic, such as project objectives, success criteria, high-level project and product requirements, and list of milestones.

Caution! In interviews, trust and proper confidentiality are essential to create an environment of honesty and thereby collect unbiased data.

Interpersonal and Team Skills. Interpersonal and team skills are an important part of the leadership skills expected from a project manager, as discussed in Chapter 2. These skills, such as meeting-management facilitation and conflict management, can be used to develop the project charter. Some good meeting-management practices include 1) run the meeting with an agenda; 2) send timely invitaions to appropriate stakeholders; 3) prepare for the meeting; 4) make sure that the meeting minutes are being taken; and 5) follow up the meeting with minutes and action items from the meeting.

The facilitation skill can be used in a meeting or in any group situation, including online, to effectively guide a group to a successful conclusion, such as a decision or resolution to an issue, based on your encouraging effective participation, considering all contibutibutions, and developing mutual understanding. To develop mutual understanding, sometimes conflict-resolution skills are warranted, such as to get stakeholders to agree on project charter aspects like project objectives, product requirements, milestones, and project success criteria.

You apply these tools and techniques on input to produce the output of the Develop Project Charter process.

Output of Develop Project Charter

The output of the Develop Project Charter process contains two items—assumptions log and project charter—as described in the following.

Assumptions Log. This item contains assumptions and constraints mostly at a strategic and operational level. They are usually recorded in the business case document and can also come from expert judgment. When the project starts, the assumptions log grows as lower-level assumptions are made due to a lack of details that affect cost estimate, schedule, plans, and so on. Assumptions are important as they give rise to risks.

An *assumption* is a factor that you consider to be true without any proof or verification. For example, an obvious assumption that you might make during planning for an in-house project could be the availability of the required skill set to perform the project. It's important to document assumptions clearly and validate them at various stages of the project because assumptions carry a certain degree of uncertainty with them, and uncertainty means risk. Assumptions can appear in both the input and the output of various processes.

A *constraint* is a restriction (or a limitation) that can affect the performance of the project. It can appear in both the input and the output of various processes. For example, there could be a schedule constraint that the project must be completed by a predetermined date. Similarly, a cost constraint would limit the budget available for the project.

Project Charter. It is a high-level document that summarizes information about the project and its intended outcome. A careful reader may already know what is in it by now, because we have been mentioning the items in it directly or indirectly. Anyhow, here they are:

- **The Project Purpose and Justification.** This includes the purpose of the project and high-level project justification, including business need for the project and return on investment.
- **High-level Project Description.** This includes key deliverables and scope, i.e., boundaries around the project.
- **High-level Project Requirements.** These are based on the needs of the customer, the sponsor, and other stakeholders.
- **Project Objectives and Success Criteria.** This explains what exactly will be accomplished to meet the purpose—that is, what the outcome of the project will be. Each objective should be measurable and have a success criterion assigned to it.

- **High-level Risks.** This is overall high-level project risk. The lower-level risks will be identified during project planning.
- **Milestone Schedule.** The charter should include a high-level schedule, such as a milestone schedule.
- **A Budget Summary.** A high-level summary of the project budget—that is, how much money is required and at what times during the project.
- **Project Manager.** Assign a project manager with specified responsibility and authority level.
- **Project Sponsor.** The name and authority level of the project sponsor authorizing the project charter.
- **Project Exit Criteria.** This states the conditions that have to be met before closing or cancelling the entire project or project phase.
- **Project Approval and Acceptance Requirements.** This item answers the following questions:
    - What are the name and responsibility of the person or committee that will approve and accept the project when it's finished?
    - What constitutes project success?
    - Who decides whether the project is successful?
    - Who signs off on the project completion?

Depending on the project and the organization, the charter may include other elements as well, such as a budget summary, a list of participating functional departments of the organization, and their roles in the project.

Caution! The project charter provides the interface between the project and the organization's strategic objectives.

As previously stated, the project charter provides the project manager with the authority to use organizational resources to run the project. Remember that, formally speaking, project charters are prepared external to project management by an individual, a committee in the organization, or the PMO. In other words, project management starts where the project charter ends. However, practically, the would-be project manager might actually be involved

in writing the project charter or a part of it. The project approval and funding will still be external to the project management boundaries.

A project charter is not a contract, as no money is involved.

Note Usually the Develop Project Charter process is performed only once or at pre-determined points in the project; for example, for a project that includes multiple phases, it may be performed at the beginning of each phase to validate the assumptions made during the previous phases.

STUDY CHECKPOINT 3.1

Q1. True or false: It is the responsibility of the project manager to develop the project charter.

Q2. True or false: A project charter is a contract between the performing entity and the entity for which it's being performed.

Q3. Which process project document interfaces the project with the organization's strategy?

Caution! It's important to realize that the approval and funding of a project occur outside the boundaries of the project. However, the project management team may help and be involved in writing the project charter, and the project manager even may be asked to get involved in developing the business case.

Once you have the project charter, you know the high-level product requirements that the project will satisfy. However, a high-level requirement written in a certain way might mean different things to different stakeholders. So, after you get the project charter, one of your next tasks will be to develop a common understanding of the project among the project stakeholders. You accomplish this by drawing or explaining boundaries around the project at a lower level—that is, what is included and what is not—thereby spelling out what exactly the deliverables are. By doing this, you are determining the scope of the project at the lower level.

After the project has been chartered, it's time to plan the project. Project planning involves determining exactly what will be done and how it will be done. Executing a project means implementing the project management plan for that project. Therefore, the project management plan contains the project

scope, which defines what needs to be done to meet the project objectives. But, how is the project management plan actually developed?

■ **Caution!** There is another process that is performed along with Develop Project Charter to initiate the project. That process is called Identify Stakeholders, which we will cover when we explore the stakeholder management knowledge area.

Developing the Project Management Plan

Congratulations, you have your project defined and initiated with the project charter. You can't wait to begin executing. But hold on! I have three questions for you. First, how do you know what exactly to execute and how? Second, when you are executing your project, how will you know that you are on the right track? Third, during the execution, how will you know that the project is performing in such a way that it will end with success? To address these and other related questions, you will need to do some planning before you begin the execution.

So, once the project has been initiated, it is time to do some planning. Project planning starts with the process of Develop Project Management Plan, which defines, prepares, coordinates, and integrates all subsidiary plans, such as scope and risk management plans, into one plan called the *project management plan*. Most of the subsidiary plans are prepared as part of other processes. One of the goals here is to develop a source of information that will work as a guideline for how the project will be planned, executed, monitored and controlled, and closed.

One reason why it is important to develop a project management plan is that not all projects need all the planning processes and to the same degree. Depending upon the complexity of the project, the project management plan can be either a summary or a collection of subsidiary plans and components. One necessary item in the plan is the baseline for at least the following project features: scope, time, and cost. A baseline is a reference against which actual project performance is compared to measure deviation.

■ **Note** The project management plan provides the basis of all the needed project work and how it will be performed.

The process of developing the project management plan, illustrated in Table 3-3, falls in the knowledge area of integration management because it coordinates the various planning processes and activities. Therefore, output from other planning processes, in addition to the project charter, are the obvious inputs to this process. The other inputs are enterprise environmental factors and organizational process assets. You take the relevant information from the project charter and elaborate that. The outputs from other planning processes refer to the subsidiary plans, such as cost or quality management plans; we will cover these processes and plans in other chapters. You have to deal with enterprise environmental factors, such as using the existing facilities and working within the given organizational structure and governance framework, following industry standards, and meeting legal and regulatory requirements. Similarly, you must work with the relevant organizational process assets: using the organizational standard policies, processes, and procedures; plan management templates, and knowledge database.

Table 3-3. The Develop Project Management Plan Process: Input, Tools and Techniques, and Output

Input	Tools and Techniques	Output
1. Project charter	1. Expert judgment	1. Project management plan
2. Outputs from other planning processes	2. Data gathering	
3. Enterprise environmental factors	3. Meetings	
4. Organizational process assets	4. Interpersonal and team skills	

To develop the project management plan, you apply expert judgment, data gathering, meetings, and interpersonal and team skills as tools and techniques. Expert judgment may be sought in the areas relevant to developing the project management plan, such as tailoring the project management process to the project needs; elaborating on a high level information from the project; and developing technical details to be included in the project management plan. Data-gathering techniques used here include interviews, focus groups, brainstorming, and checklists. A checklist in this case would be a list of items or information to include in the project management plan. While developing the plan you check against the list to verify that each item in the list has been included. Other data-gathering tools mentioned, which were explained in the development of the project charter, may be used here in the context of project management. The interpersonal and team skills are also the same as explained in the section on developing the project charter: conflict management, facilitation, and meeting management.

By applying these tools and techniques to input, you produce the output of the Develop Project Management Plan process, which is, well, a project management plan. Plans and baselines of a typical project management plan are listed in Table 3-4 with the chapter numbers where they are discussed in detail. Depending to the project's needs, additional plans and other components may be developed and included in the project management plan, such as a change management plan and a configuration management plan.

Table 3-4. Plans and Baselines of a Typical Project Management Plan

Plan Component	Chapter Number	Plan Component	Chapter Numbers
Scope management plan	4	Requirements management plan	4
Schedule management plan	5	Cost management plan	7
Quality management plan	10	Resource management plan	6
Communications management plan	9	Risk management plan	11
Procurement management plan	12	Stakeholder engagement plan	8
Scope baseline	4	Schedule baseline	5
Cost baseline	7	Performance measurement baseline	1, 4, 5, 7

Caution! Some documents, which are not included in the project plan, are produced and used at different times throughout the project lifecycle. They are simply called project documents.

Now, you have a project management plan. Assuming that you also have all other needed project documents, can you now start project execution? Yes, but once the project execution begins, it needs to be managed using appropriate processes, such as the Direct and Manage Project Execution process.

Directing and Managing Project Work

The project work defined and scheduled in the project management plan is performed using the Direct and Manage Project Execution process. This is where the rubber hits the road. This integration process manages work planned in all knowledge areas by interacting with processes across the process groups. This process is used to manage various technical and organizational interfaces in the project to facilitate smooth execution of the project work.

The three main functions of directing and managing project work are as follows:

- Execute the planned project activities to produce deliverables in order to meet the project objectives.
- Produce work performance and related change requests.
- Implement the approved changes, defect repairs, and other actions.

The key words during this process are *implement*, *perform*, and *change*. Table 3-5 illustrates the Direct and Manage Project Work process with its input, tools and techniques, and output.

Table 3-5. The Direct and Manage Project Work Process: Input, Tools and Techniques, and Output

Input	Tools and Techniques	Output
1. Project management plan 2. Project documents 3. Approved change requests 4. Enterprise environmental factors 5. Organizational process assets	1. Expert judgment 2. Project management information systems 3. Meetings	1. Project deliverables 2. Project performance data 3. Issue log 4. Updates: Project management plan, Project documents, Organizational process assets

Input to Directing and Managing Project Work

The input to directing and managing project work mainly consists of the items that need to be implemented—makes sense. Information on the project work that needs to be performed to produce project deliverables is the major input to this process. The specific input items are discussed in the following.

Project Management Plan. Directing and managing project execution is all about implementing the project management plan, which contains all the major subsidiary plans, such as the scope management plan, cost management plan, and schedule management plan. Obviously, it also includes important outputs from other planning processes, such as the scope baseline, the schedule baseline, and the cost baseline. It also describes how the work will be executed so as to meet the project objectives and produce deliverables that satisfy the planned requirements.

Project Documents. These include: 1) milestone list that shows scheduled dates for specific milestones; 2) project schedule that shows work activities, their durations, needed resources, and scheduled start and finish dates; 3) project communication, which includes performance reports, deliverables status, and other useful information; 4) requirements traceability matrix, which traces whether the deliverables satisfy the planned requirements; 5) change

log, which contains the status of all change requests; 6) risk report, which contains information on identified risks; and 7) risk register, which provides information on threats and opportunities that could possibly impact project execution.

We will explore these documents in upcoming chapters.

Approved Change Requests. As shown in Table 3-5, the Direct and Manage Project Work process generates the work performance data, which becomes an input item to the Monitor and Control Project Work process, which in turn generates the change requests and performance reports, both of which are input to the Perform Integrated Change Control process. The Perform Integrated Change Control process outputs the approved change requests, which become an input item back into Direct and Manage Project Work. The approved change requests include those reviewed and approved by the project manager or change control board (CCB), depending on the nature of the each change request.

Enterprise Environmental Factors. Items in this category that can be of influence or need to be considered in directing and managing project work include organizational structure and culture; company infrastructure, such as facilities and equipment; and stakeholder risk thresholds, such as allowable cost overruns. Putting it in context, while executing this process, you will be interacting with other processes and departments in your organization. In general, a project team includes people from different departments. Usually, the reporting relationships within the same department are very well defined and structured. However, the relationships between different departments (especially between individuals from different departments at the same level of authority) are not well defined. So, managing such project interfaces in a given organizational structure and culture is a crucial function of a project manager during project execution. Generally speaking, project interfaces are the formal and informal boundaries and relationships among team members, departments, organizations, or functions—for example, how the development department and the QA department interact with each other's departments while working on the same project. The project manager has to manage these interfaces.

Organizational Process Assets. Items in this category that can be useful or need to be considered in directing and managing project work include the following:

- Management procedures and management databases with historical information for defining, identifying, controlling, and tracking issues and defects
- Performance measurement database used to store and make available performance measurement data

- Procedures related to change control and risk control
- Information from previous projects that can be used in this process, such as schedule, performance measurement baselines, risk registers, risk reports, and lessons learned repository

For example, a defect management database may contain a list of validated defect repairs with information on whether a previously performed defect repair has been accepted or rejected. This will tell you whether you need to implement the defect repair again; of course, you have to look at that information in the context of that time and that project.

In a nutshell, the project management plan and approved change requests are the major inputs to directing and managing project work because executing the project is all about implementing the project management plan along with the approved change requests.

You direct and manage project work by using some tools, which will be discussed in the next section.

Tools and Techniques for Directing and Managing Project Work

The major tool used to direct and manage project work is the project management information system (PMIS), which is a collection of IT tools, such as software to gather, integrate, and disseminate the output of project management processes; automated scheduling tools; a configuration management system; an information entry, storage, and distribution system; and interfaces to other online systems. This PMIS is used to facilitate processes from the initiation stage all the way to the closing stage. For example, Microsoft Project is a software tool that lets you create and manage a project schedule.

Another tool used in directing and managing project work is expert judgment, which depends on the issue and the available resources. Expert advice or training relevant to this process may include topics such as technical knowledge of the industry, with a focus on the area of the project; cost and budget management; organizational governance; legal and procurement; and legislation and regulations.

Meetings can also be used as a tool for this process. There may be various types of needed meetings, including kick-off, technical, iteration planning, steering group, problem solving, and progress update.

The project is executed to produce some outcome—the deliverables—which will be the output of directing and managing the project work.

Output of Directing and Managing Project Work

When the project is being executed, at each point in time there are some deliverables with parts completed, some issues that have arisen, performance data that has been produced, and a status for the project that can be reported to the stakeholders. These important output items, along with others, are discussed in the following list.

Deliverables. A deliverable is a unique and identifiable project outcome (i.e., product, service, or result) identified in the project management plan that must be generated to complete the project. The core purpose of executing the project management plan is to produce deliverables.

To produce the right deliverable, change control must be applied regularly, starting from the first version of a deliverable. In addition to the work that produces original deliverables, the following items are implemented during project execution.

Work Performance Data. When the project work is being performed, we observe and take measurement on how we are doing. These observations and measurements are called work performance data. This is raw data that can be analyzed to draw useful conclusions. The following are a few examples:

- Deliverables status; e.g.; completed or 30 percent done
- Overall schedule progress
- Schedule activities: actual start and finish dates
- Costs incurred: $100,000 spent so far
- 30 change requests made, 10 defects found

Issue Log. Throughout the project, you will face issues, e.g.; problems, inconsistencies, and conflicts. These issues need to be resolved so they do not start impacting the project negatively. To start the process, you enter an issue into an issue log with the following information: issue type, who raised the issue and when, issue description, priority, who the issue is assigned to, target resolution date, status, and final resolution.

The issue log is updated during monitoring and controlling activities.

Change Requests. During the execution of the project work, requests for changes may arise as a result of various issues and may affect certain aspects of the project, such as the following:

- Project scope
- Project cost
- Project schedule

- Policies or procedures
- Plan

These change requests might come from inside or outside the performing organization and can be optional or mandated legally or contractually. These change requests must be approved before they can be processed and implemented and can include the following types:

- **Direct Change Requests.** These are changes that are not a result of any other action in the project; e.g.; changed market conditions are demanding a new product feature. This may result in requests for changes to project plan, scope, schedule, or/and cost. Of course, these changes can also result from other change requests, listed next.
- **Indirect change requests.** These include the following:
    - **Defect Repairs.** This is a deliberate action to modify a nonconforming product component. For example, there could be a list of defects found during the quality assurance (QA) process that seek approval for repairs.
    - **Corrective Actions.** This is a deliberate action to bring the performance of the project work back on track and in line with the project management plan. For example, the QA process can recommend corrective actions to improve quality, which are directions for executing the project work to bring the expected project performance into conformance with the project management plan.
    - **Preventive Actions.** These are directions to perform an activity so as to prevent something from happening in the future and to bring the performance of the project work back on track and in line with the project management plan. For example, activity that will reduce the probability of negative consequences associated with project risks; e.g.; these preventive actions are recommended by the QA process during process analysis.
    - **Updates.** These change requests are made as part of controlling a new or modified idea being implemented. For example, the update request could be for a project document and plan with that intention, i.e., implement the idea.

Caution! Most of these change requests are to keep the project execution aligned with project management plan.

These change requests to the Perform Integrated Change Control process and the approved requests come back as an input to the Direct and Manage Project Work process for implementation.

Updates. As a result, or after the implementation of approved change requests, you may need to change some elements of the project management plan, such as any project baseline, resource management plan, requirements management plan, or communication management plan. You may also need to modify any of the input process documents to reflect the project work done and changes implemented.

The project work will produce documents and information, which you will need to store in the knowledge databases repository. This way, you will be updating organizational process assets.

Note The key benefit of the Direct and Manage Project Work process is that it provides overall management of the project work and the resulting deliverables in an integrated way. This improves the odds of project success.

The Direct and Manage Project Work process is a high-level umbrella process under which other executing processes are running, which will be discussed in forthcoming chapters. However, all these processes need to be monitored and controlled.

In the monitoring and controlling process group, the Monitor and Control Project Work process and the Perform Integrated Change Control process belong to the project integration management knowledge area.

Monitoring and Controlling Project Work

Monitor and Control Project Work is the high-level process for monitoring and controlling the project's progress to ensure that the project is on its way to meeting the objectives laid out in the project management plan. *Monitoring and controlling* here means tracking, reviewing, and reporting the project progress. You monitor by collecting data on or measuring some project aspect and assessing how the measurements and trends would affect project performance. You control by determining change—e.g.; corrective or preventive actions or modifications to the plan—following up with action, and then checking whether the actions taken have resolved the problem.

Some of the major tasks performed during this process include the following:

- Monitor the project performance by comparing it against the project management plan in terms of parameters such as cost, schedule, and scope.
- Evaluate performance to determine whether it needs to be controlled by taking corrective or preventive actions.
- Monitor the project by analyzing raw performance data to support status reporting, progress measurement, and predictions.
- Monitor risks by tracking and analyzing the already identified project risks and by identifying new risks.
- Controlling risks by managing the execution of risk response plans when the risks occur.
- Maintain an accurate and timely information base regarding the project as it progresses.
- Monitor and control changes and monitor the implementation of approved changes, such as from the performance data.

Tip The most important overall goal of the Monitor and Control Project Work process is to make sure that the project remains aligned with the organization's business need from which it originated.

The Monitor and Control Project Work process is illustrated in Table 3-6.

Table 3-6. The Monitor and Control Project Work Process: Input, Tools and Techniques, and Output

Input	Tools and Techniques	Output
1. Project management plan	1. Expert judgment	1. Work performance reports
2. Project documents	2. Data analysis	2. Change requests
3. Work performance data	3. Decision making	3. Updates: project management plan, project documents, organizational process assets
4. Agreements	4. Meetings	
5. Enterprise environmental factors		
6. Organizational process assets		

Input to Monitor and Control Project Work

The major inputs to this process are the project management plan, to look for any aspect of the project, and work performance data for analysis that comes from directing and managing the project work. We also have project documents, including 1) **milestone list** with scheduled dates for specific milestones to check if they are being met; 2) **project schedule forecasts** to determine if the project is within defined schedule tolerance ranges; 3) **basis of estimates** for information on how the various estimates are made and how they can be used to determine responses to variances; 4) **cost forecasts** for project's past performance, used to determine if the project is within the defined budget tolerance ranges and to identify any necessary change requests; 5) **issue log** shows who is responsible for resolving specific issues by a target date; 6) **assumptions log** for information on assumptions and constraints identified as affecting the project; 7) **change log** that contains the status of all change requests; 8) **risk register** for information on threats and opportunities that could possibly impact project execution; 9) **risk report** for information on the overall project risks and also on specific individual risks, such as risk sources; 10) **quality reports** for information on quality management issues, corrective actions, recommendations for project, processes, and product improvements, and summary of findings from the Control Quality process; 11) **lessons learned register** for information on effective responses for variances, as well as corrective and preventive actions.

You will learn the details of all these in the chapters ahead.

Enterprise environmental factors used as inputs to this process include the project management information system, infrastructure for facilities and equipment and so forth, the risk tolerance level of the stakeholders, and industry and government standards. The organizational process assets that can be used to perform this process include financial control procedures, management procedures regarding issues and defects, risk control procedures, the process measurement database, and knowledge database repository for lessons from past projects.

Tool and Techniques for Monitor and Control Project Work

The tools and techniques used for the Monitor and Control Project Work process are meetings, decision making, expert judgment, and data analysis. You already know about meeting management by now.

Decision-making techniques. Depending on the organization, project, and subject matter; different decision-making techniques may be used such as the following:

- **Decision by Voting**. This can take different forms—by simple majority, by two-thirds majority, or by open or unanimous voting. In a voting system calling for a plurality, a group or option carrying the largest vote wins even if it's not a majority. This situation arises when there are more than two alternatives. A plurality with two alternatives is simply a majority method. One vote can represent an individual or a group.
- **Autocratic Decision Making**. This technique is where one individual makes the decision instead of the entire group.
- **Multicriteria Decision Analysis**. This is the analytical technique used to make a decision. In this technique, we have a set of predefined criteria, and we use a number of systematic analytical methods to evaluate the requested changes. Then, we make the decision by comparing the analysis result to already chosen criteria.

Expert Judgment and Data Analysis. Expert judgment can be sought if needed in areas relevant to this topic, such as contract management, risk management, technical knowledge of focus area of the project, decision-making techniques, and any of the data analysis methods listed in Table 3-7.

Table 3-7. Data Analysis Methods Listed for the Monitor and Control Project Work Process

Any Technique	Need	Chapter
Cost-benefit analysis	Helps to determine the best corrective action in terms of cost in case of project deviations	7
Earned-value analysis	To get an integrated perspective on scope, schedule, and cost performance	7
Root-cause analysis	To find out the main reasons of a problem; e.g.; identify the reasons for a deviation as well as the areas the project manager should focus on to effectively achieve the project objectives	11
Trend analysis	Forecast future performance based on past and present results	3, 7
Variance analysis	Determine and analyze the differences (or variance) between planned and actual performance	7
Alternatives analysis	Selects a corrective action, a preventive action, or both to implement as a response to deviation	5

Output for Monitor and Control Project Work

The output items of this process are described in the following.

Work Performance Reports. The raw work performance data, a main input into this process, is turned into information by data-analysis techniques that are then presented in work performance reports. These reports are distributed in physical or electronic form among the appropriate stakeholders for various purposes, such as to raise awareness, help make decisions, and take action. Status reports and progress reports are two common examples of work performance reports. To help the stakeholder effectively comprehend the information, these reports can use appropriate presentation tools, such as tables, charts (e.g.; reserve burndown charts), histograms (e.g.; defect histograms), and graphs (e.g.; earned value and trend line graphs).

Change Requests. You will be comparing the work performance data or the analysis thereof with the planned performance. The deviation will produce some change requests, such as to adjust project scope, product scope, quality requirements, or schedule or cost baselines. Change requests may necessitate the collection and documentation of new requirements. We already have discussed such changes in detail in the Direct and Manage Project Work process coverage.

Caution! Original change requests, such as in project scope, product scope, or cost line, if approved, can trigger other changes, such as those to the project management plan, project documents, or product deliverables.

Project Document Update. Based on the results of data analysis, any input document may be updated. For example, new risks identified will be recorded in the risk register, new issues will go into the issue log, and changes in cost forecasts will modify the cost forecasts document.

Caution! Monitor and Control Project Work is a high-level umbrella process. Most of its tasks are actually performed using the lower-level, more-specific processes discussed in the upcoming chapters.

STUDY CHECKPOINT 3.2

Q1. The performance of a project is measured against which planning element?

Q2. Can you name four baselines?

As you have learned, change requests arise from monitoring and controlling the project work and from directing and managing project work, and may originate from any other source, such as the stakeholders. These requests must be processed through the integrated change control process, formally called the Perform Integrated Change Control process.

Performing Integrated Change Control

The Perform Integrated Change Control process is all about processing change requests, which includes evaluating them; deferring, rejecting, or approving them; and managing the implementation of approved changes and the changes resulting from this implementation.

A project rarely runs exactly according to the project management plan, and therefore deviation will inevitably occur. The change requests can come from evaluating the project performance to bring the project in line with the project management plan, or they can come from other sources, such as the stakeholders. Regardless of where they originate, it is the project manager's responsibility to manage all the changes, which includes getting the changes rejected or approved, ensuring the approved changes get implemented, and changing the affected plans and documents accordingly.

Note other things about changes and this process:

- The Perform Integrated Change Control process is used to manage changes to the project from project initiation through project closure.
- **Process Changes.** Depending on the project, performing organization, and the particular request, the authority to determine whether it be deferred, rejected, or approved might lie with the project manager, the sponsor, or some kind of committee, such as a change control board (CCB). The CCB may consist of individuals from upper management and other stakeholders.

- Even after CCB approval, an approved change request may require the approval of other stakeholders, such as customer or sponsor.
- As noted earlier, to incorporate the approved changes, some other changes may be necessary, such as updating the project baseline (cost, schedule, and scope) to maintain their integrity.

Tip Especially in a startup organization, you will notice quite often that changes make their way through the back door—for example, a product manager talking to an engineer directly and introducing changes. Do not consider yourself an opponent of changes by default, but you do need to manage changes and make sure each change goes through the integrated change control process. So, when it comes to changes, the key word is *control*, and not necessarily *oppose*.

Table 3-8 shows the integrated change control process. The change requests that need to be approved are the obvious input to this process.

Table 3-8. The Perform Integrated Change Control Process: Input, Tools and Techniques, and Output

Input	Tools and Techniques	Output
1. Project management plan	1. Expert judgment	1. Approved change requests
2. Project documents	2. Change control	2. Updates: project management plan, project documents
3. Work performance reports	3. Data analysis	
4. Change requests	4. Decision making	
5. Enterprise environmental factors	5. Meetings	
6. Organizational process assets		

Tip The key benefit of this process is that the changes get documented; they are considered, deferred, rejected, or approved; approved ones are implemented in the entire context of the project; and changes resulting from the implementation are managed. This reduces the risk that would prevail absent this process.

Input to Integrated Change Control

Each requested change and recommended action must be processed through the Integrated Change Control process. The approved changes have their effects on the project management plan, and therefore the plan needs to

be updated accordingly. The following are the input items to the Integrated Change Control process.

Project Management Plan. This is needed for change-related information. The change management plan contains information about managing the change control process along with the roles and responsibilities of the change control board (CCB) and the role of the project manager in the change request approval process. The other relevant project plan component includes configuration management and scope, schedule, and cost baselines. We also need the project plan because some of its components may need to be updated as a result of the applied changes.

Project Documents. The project documents that we may need for information and updating include basis of estimates, requirements traceability matrix, and risk report, discussed earlier.

Work Performance Reports. The performance report is input because the reported performance deviations from the plan are important when evaluating the resulting change requests. We described these reports in the previous section.

Change Requests. These are obvious inputs. A requested change goes through an approval process, where it can be approved, rejected, or delayed. Enough has been said about these changes in this and previous sections. As said earlier, change requests may include the following types of recommendations:

- Recommended corrective actions
- Recommended preventive actions
- Recommended defect repairs

These recommendations might arise from different sources, such as performance evaluations, output of various control processes, and stakeholders, as illustrated in Figure 3-2.

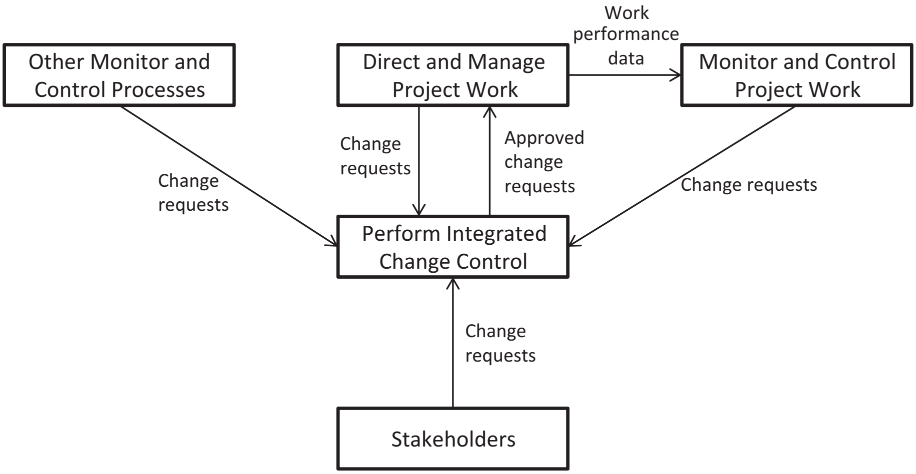

Figure 3-2. Big picture of change control

Enterprise Environmental Factors. The enterprise environmental factors that can influence the integrated change control process include organizational governance; contracting and purchasing constraints; legal and regulatory requirements and constraints; and government and industry standards.

Organizational Process Assets. The following items in the organizational process assets can influence the change control process:

- **Organizational Procedures.** Your organization may have proper procedures related to change control—for example, how to modify documents, such as plans; how to process (evaluate, approve, or reject) changes; and how to implement the approved changes.
- **Project Files.** Project files from previous projects may be a useful input to the change control process in order to learn from the past.
- **Change Knowledge Base.** This is the knowledge base that can be used for configuration management, such as official company standards and policies and project documents; i.e., changes in different versions of them.

So, what tools and techniques are available to process these requests and recommendations?

Tools and Techniques for Integrated Change Control

The main tools used in this process are discussed next.

Expert Judgment and Meetings. Expert judgment can be made on the topics such as technical expertise of the stakeholders to evaluate change requests; risk management; configuration management; and legal issues, legislation, regulations, and procurement. The project manager or project management team can also hold meetings with experts and the change control board to evaluate changes and make approval and rejection decisions.

Change Control Tools. The change control tools are actually manual or automated tools for both configuration control and change control. *Configuration* refers to a specific arrangement of elements in a particular figure, form, or combination. Some examples include the setting of options in a computer program, distribution of electrons in a particular atom, and spatial arrangement of atoms in a molecular bond. Configuration control is mainly about deliverables and processes—for example, facilitating to identify, document, report, verify, and audit them—whereas change control is mainly about change—facilitating to identify, document, postpone, reject, approve, and track changes to the deliverables, baselines, project documents, and so forth.

Data-Analysis and Decision-Making Techniques. These techniques are used to assess the change requests and decide whether to postpone, reject, or approve them. The data-analysis techniques may include alternatives analysis to help make decisions about which corrective actions, preventive actions, or both to implement as a response to deviation, if the change request is accepted; cost-benefit analysis to determine if the change implementation is worth its cost; and so on.

We can easily apply decision-making techniques by using voting, autocratic decision making, and multicriteria decision analysis, which were discussed in the section on the tools and techniques for the Monitor and Control Project Work process.

Output from Integrated Change Control

The changes that are processed through the Integrated Change Control process will be deferred, rejected, or approved. As a result of the approved changes, the project management plan and project document might need to be updated. Accordingly, the following are the output items of the Integrated Change Control process.

Approved Change Requests. You must make sure not only that the approved change requests are implemented through the Direct and Manage Project Work process, but also that the status or info about the deferred and rejected change requests are communicated to the stakeholders who requested the change.

The dispositions of all change requests are recorded in the change log as a project document update.

Project Plan and Project Document Updates. As a result of approved changes, components of the project management plan may need to be updated, along with the project scope, baselines, and any subsidiary plans. Also, project documents may need to be updated, such as the change log, which is used to record changes that happen during the project lifecycle.

Caution! During document updates, changes to any baselines are made in reference to the last baseline version of baseline, thus keeping all the versions intact in order to preserve the integrity of the baselines for the purpose of having historical data of past performance.

STUDY CHECKPOINT 3.3

Q1. Many processes in the monitoring and controlling process group generate change requests. Name the process in this process group that is used to approve or reject the change requests.

Q2. Name the processes and other sources that can generate the change requests.

Managing Project Knowledge

The Manage Project Knowledge process is used to help meet the project objectives and contribute to organizational knowledge and learning by creating new knowledge and using existing knowledge. Existing knowledge is also used in the process of creating new knowledge in the course of this process.

Caution! From the definition of Manage Project Knowledge, it should be clear that managing knowledge is not just about recording or documenting the knowledge to share it, nor is it just about yielding the lessons learned to be used in the future projects.

In this chapter, we have introduced the concepts of data, information, and knowledge. When any confusion arises, let's ask a question: what is the difference between data, information, and knowledge? Figure 3-3 presents a simple illustration of the relationship between these three concepts. Data are raw facts, such as that an activity was finished in 30 days of work, while information is the processed or interpreted data that have some use and

implications, such as that an activity was finished in 30 days of work when it was planned to be finished in 20 days of work. Both data and information can be presented in plots. Information combined with our experience, intuition, and existing knowledge produces knowledge with predictive ability, such as that an activity was finished in 30 days of work when it was planned to be finished in 20 days of work, so (adding other pieces of information) the project will be 7 days late and will cost $2,000 more.

Figure 3-3. Relationship Between Data, Information, and Knowledge

Back to the Manage Project Knowledge process, which is performed throughout the project. The flow of knowledge is an important part of knowledge management. In fact, the most important task and challenge of knowledge management is to create an environment where people trust each other and are motivated to learn and share knowledge.

The inputs, tools and techniques, and outputs of the process are depicted in Table 3-9.

Table 3-9. The Manage Project Knowledge Process: Input, Tools and Techniques, and Output

Input	Tools and Techniques	Output
1. Project management plan	1. Expert judgment	1. Lessons learned register
2. Project documents	2. Information management	2. Updates: project management plan, organizational process assets
3. Project deliverable	3. Knowledge management	
4. Enterprise environmental factors	4. Interpersonal and team skills	
5. Organizational process assets		

Input to Manage Project Knowledge

The use the input items in this process is discussed in the following.

Project Management Plan and Project Documents. The project documents relevant to this process that can be used include 1) **the lessons learned register** to learn about effective practices in knowledge management and to add new ones; 2) **project team assignments** for information on the skill set and experience currently available in order to figure out missing knowledge needed for the project; 3) **the resource breakdown structure** for information on the team's composition; again, this may indicate the available

and missing but required knowledge for the project; and 4) **the stakeholder register** for details about the already identified stakeholders that may reveal what knowledge or skills they have.

Project Deliverables. These are needed to figure out what knowledge is needed to produce them, and also to figure out the lessons learned.

The Enterprise Environmental Factors. The enterprise environmental factors that can influence the Manage Project Knowledge process include 1) **knowledge expertise in the organization;** 2) the **culture** of the organizational and project stakeholders, which will influence the evaluation and sharing of knowledge; 3) **geographic distribution of facilities and resources**; this will help determine tools and techniques for knowledge flow—obtaining, providing, and sharing knowledge; and 4) **legal and regulatory requirements and constraints**; e.g.; confidentiality of project information will influence the knowledge flow.

The Organizational Process Assets. Some organizational policies, processes, and procedures may influence knowledge management, such as authorized technology and social media; confidentiality and access to information; and the use of copyrighted information. Also, personnel administration, such as employee development and training records and skill set records, may reflect attitudes toward learning and sharing knowledge. Furthermore, organizational communication requirements may have an influence too. For example, formal and strict communication requirements help learning and sharing knowledge, while an informal environment may be more effective for improving the existing knowledge, creating new knowledge, and integrating knowledge from diverse stakeholders. Knowledge and information transfer procedures apply to reviews before, during, and after projects and project phases to identify, capture, and share lessons learned from the current project and other projects.

Obviously, the knowledge database repository is another organizational process asset that helps with knowledge management.

Tools and Techniques for Managing Project Knowledge

Two major types of tools and techniques used for this process are information management and knowledge management. All of them, however, are discussed here.

Expert Judgment. Expert judgment may be sought on topics in the areas of information and knowledge management, including the available tools in these areas and relevant information and knowledge from other projects.

Information Management. This type of tool helps people connect to the information sources where they can store, obtain, and share information. Some examples are project management information; system library services; and the lessons learned register and tools to store, edit, and retrieve entries into and from this register. E-mails, web browsers, podcasts, online communities of subject matter experts, and other such web applications are some additional examples.

Knowledge Management. This type of tool helps people connect to share data, information, and knowledge and to work together to create new knowledge. Some examples are meetings, including virtual or online meetings; networking, including face-to-face and online social media; online forums in which to ask and answer questions; knowledge-sharing events such as seminars, conferences, and knowledge fairs; and learning workshops.

Interpersonal and Team Skills. These skills were already discussed in this and the previous chapter. However, leadership, networking, active listening, facilitation, staying on the topic, and being respectful and courteous to people are particularly important.

Output of Managing Project Knowledge

The output of this process is discussed next.

Lessons Learned. The main output from managing project knowledge is the lessons learned from the project, which are recorded into the lessons learned register, a document that is created the first time we run this process, or earlier, and updated subsequently. This can be a well-structured document that links certain fields to each category, such as description of the situation, impact on the project, recommendations, and proposed and implemented actions. The categories, for example, may be the risks realized, challenges faced, problems, and opportunities. To ensure the efficiency of capturing the content and its effectiveness, appropriate technology such as audio, pictures, and videos can be used.

Updates. At end of the project or project phase, lessons learned are transferred to the lessons learned repository in the knowledge database of the organization; i.e., this component of the organizational process assets is updated. Other organizational process assets in addition to the lessons learned repository may also be updated. Other updates may also happen as a result of this process.

Tip The key benefits of the Manage Project Knowledge process is that new knowledge is created or existing organizational knowledge is improved, and in the process of this creation or improvement the existing knowledge is used. Moreover, the created or improved knowledge is used in the organization's operations and in future projects or future phases of the current project.

The project deliverables that have been accepted through the scope verification process still need to go through final transition to the appropriate party, such as the customer or the sponsor. In other words, the project needs proper closure.

Performing Project Closure

Closing the project means finalizing all activities across the project by using the Close Project process. The formal name of the project closure process is Close Project or Phase because it can also be used to close a phase in a multiphase project. Project closure includes ensuring that all the planned work is completed, the planned outcome has been delivered, the project or phase information is archived with the organization, and team resources are released. You also need to determine and coordinate the procedures required for verifying and documenting the project deliverables.

The items that describe what the project was planned to deliver and what it has delivered would be the obvious inputs to the process of closing the project. The process is illustrated in Table 3-10 with its input, tools and techniques, and output.

Table 3-10. The Close Project or Phase Process: Input, Tools and Techniques, and Output

Input	Tools and Techniques	Output
1. Business documents	1. Expert judgment	1. Final project outcome
2. Project charter	2. Data analysis	2. Final report
3. Procurement documents	3. Meetings	3. Updates: lessons learned register and other project documents, organizational process assets
4. Agreements		
5. Project management plan		
6. Project documents		
7. Accepted deliverable		
8. Organizational process assets		

Tip Not only the completed projects, but also the terminated projects must be formally closed using the processes of the closing process group.

Input to the Close Project Process

You need a list of project deliverables that have been verified through the Verify Scope process and will go through the transition procedure. The project management plan contains guidelines on how to close the project. These and other input items are discussed in the following list:

- **Two Business Documents and Project Charter.** The business case document and the benefits management plan document are used to verify if the deliverables are aligned with the business need and if the expected benefit would still justify the project that has been executed. The project charter document is needed to verify if the project success criteria and the approval requirements and so forth have been met.
- **Agreements and Procurement Documentation.** These will be needed to verify the fulfilment of procurement and agreements, to be used in lessons learned session, and to close the contract.
- **Project Management Plan.** This defines how to close the project and will be useful in establishing the project closure procedure. The project management plan is also used in verifying and accepting the project deliverables because it explains what deliverables are expected. Note, however, that the Validate Scope process to verify scope belongs to the scope management knowledge area and monitor and control process group, and will be covered in the next chapter.
- **Project Documents.** As you can imagine, we need quite a few project documents in this process for the purpose of verification, compliance, completion, evidence, evaluation, lessons learned session, and archive. For example, we need the issue log to verify that there is no open issue; basis of estimates to evaluate how the estimates compared to the actual result regarding items such as duration, cost, and resources; requirements documentation as evidence of compliance; and change log for lessons learned and archive. Other examples may be assumptions log, lessons learned, milestones list, project communications, quality control measurements, quality report, and risk register documents.

- **Accepted Deliverables.** This refers to the deliverables that have been verified through the validate scope process, discussed in the next chapter. That means these deliverables meet the scope requirements acceptance criteria and are accepted by the customer or sponsor. In case of a phase or cancelled project, these may also include incomplete deliverables. The deliverables may be represented here by approved product specifications, delivery receipts, work performance documents, and so on.
- **Organizational Process Assets.** These can include project closure guidelines or requirements—for example, regarding product validation and acceptance criteria, final project audits, project evaluations, contract closure, and knowledge transfer. Also, you can learn from the historical information what kind of project documents you need to archive and in what detail you want to review the project to gather and store lessons learned. Your organization may also have a transition criteria or procedure for handing the product of the project to the appropriate party.

These input items provide information about what the project was supposed to deliver and what it has delivered. You use this input and some tools and techniques to carry on the project closure.

Caution! It's important to understand the flow of project deliverables through different processes. They are generated by the Direct and Manage Project Work process, verified through the Quality Control process, accepted by the customer through the Validate Scope process, and transitioned to the appropriate party through the Close Project or Phase process.

Tools and Techniques for the Close Project Process

The tools and techniques used for closing the project are data analysis, expert judgment, and meetings. Data analysis may use techniques such as document analysis, regression analysis, trend analysis, and variance analysis. Document analysis refers to using documents to obtain or extract the information relevant to this process, such as organizational assets improvement, lessons learned, and knowledge archived for future projects. Regression analysis is used to determine the relationship between different project variables impacting the project outcome. That information will be useful for the projects. The other two techniques, trend analysis and variance analysis, are shown in Table 3-7.

Expert advice may be obtained on topics related to closing the project. There will be lots of meetings regarding the project closure activities, such as closing the contract, validating the exit criteria, confirming the acceptance of deliverables, evaluating the stakeholders' satisfaction, holding lessons learned sessions, wrapping up, and celebrating.

STUDY CHECKPOINT 3.4

Q1. Name the processes used to generate:

a. Lessons learned register

b. Lessons learned

Q2. For what do we need data analysis during the Close Project process?

Caution! The formal name of the process to close the project or a phase of it is Close Project or Phase. However, like other processes, I also refer to it by informal names, such as close project or project closure. You should know the formal name of each process and then be able to recognize from context when it's being referred to in an informal way. This will help you in the exam, and more importantly in real-world project management.

Output of the Close Project or Phase Process

Project closure accomplishes three main elements—completion of all the closing procedures; final acceptance of the project deliverables by the customer, including handing over the deliverables to the appropriate party; and reviewing the project and archiving project-related documents. This is reflected in the following output items.

Final Project Outcome Transition. This means that the project outcome—i.e., product, service, or results—has been delivered and transitioned (handed over) to the appropriate party to maintain and support it throughout its lifecycle. An appropriate party could be, for example, another organization or a different department or group in the same organization.

Final Report. This presents a brief review and summary of different project aspects in the context of project performance. For example, the project aspects could include scope, cost, and quality objectives. It can state the criteria used to evaluate the scope and cost, whether that criteria was met by the final outcome, and what the reasons were for any variance. Similarly, it can include what criteria were used to evaluate the overall project quality and

product quality, and the reasons for quality variances. Moreover, the report can summarize the procedure and results of final project outcome validation.

Updates of Lessons Learned Register and Organizational Process Assets. The project closure process updates project documents and the organizational process assets.

- **Project Documents.** The lessons learned are entered into the lessons learned register. They can cover any project-related topics. Any other project document may also be updated. Every ongoing document has at least one update: final version.
- **Organizational Process Assets**. Documents and lessons learned from the project are added to the organization's knowledge database for various purposes, such as the following:
    - For the record
    - To help for future projects
    - To support the product or service from the project under closure

This includes all types of important documents, from *project documents* such as the project management plan and documents regarding scope, schedule, cost, baseline, etc. to documents about **lessons learned and knowledge accumulated** throughout the project lifecycle; and from *project closure documents* regarding scope validation, agreements, and transfer and customer acceptance of the final product, etc., to *operational and support documents* such as those needed in order to operate and support the product or service resulting from the project under closure.

STUDY CHECKPOINT 3.5

Q1. What is the first process you perform in managing a project?

Q2. What do you need before you can begin initiating your project?

Making Project Management Common Sense

By now, you must have noticed some of the common inputs, tools and techniques, and outputs. Let's make them part of the project management common sense.

Enterprise Environmental Factors and Organizational Process Assets. The enterprise environmental factors (EEF) and organizational process assets (OPA) are very common inputs to the processes. If you master the EEFs and OPAs discussed in the previous chapter and applied in this chapter, then knowing the definition of a process, you should be able to figure out what EEFs and OPAs the process would need as input. They would be needed to help produce the output. Also note that sometimes OPAs are needed because they need to be updated as part of the process output.

Project Documents. The same is true for project documents. If you know the names of most of the project document and what they include, then by knowing the definition of a process, you should be able to tell what project document the process would need as input. Again, the process may need a document to help produce output, including the case where the output item is to update the document.

Expert Judgment and Meetings. There are common tools and techniques for many processes. Knowing what the process is supposed to do reveals the topics involved, and those are the topics that may possibly need expert judgment on stating the obvious. Similarly, by knowing the project topics and activities it will become clear to you what kinds of meetings you will be holding during the process. And general rules of good meeting management remain the same—timely invitations to appropriate stakeholders, running the meeting on agenda, starting and finishing on time, and follow-up action.

So, the coverage of these common inputs, tools and techniques, and output items in the upcoming chapters will assume that you have developed the skills just described.

Tip Although the standard project processes are the same for each organization, the details and the manners in which they are implemented might be different for different organizations. Each organization can develop its own implementation details, which consist of items such as detailed steps for how to carry on the project processes, templates, meetings, and procedures.

Summary

The project is initiated, planned, and executed in pieces, and all those pieces are related to each other and need to come together. That is where integration management comes in, which includes developing the project charter, developing the project management plan, directing and managing project work, monitoring and controlling project work, performing integrated change control, managing project knowledge, and closing the project or a phase of the project. You develop the project charter based on two business documents, namely business case and project benefit management plan, hence interfacing the project with the organization's business need and with the project charter. Then, you develop the project management plan by taking the project charter and output of many other planning processes as input. The project management plan becomes an input to all other integration processes. This virtually means that executing, monitoring and controlling, and closing the project are equivalent to implementing the project management plan.

As a project manager, you manage project execution using the Direct and Manage Project Work process, which will generate change requests that must be processed through the Perform Integrated Change Control process that in turn sends approved change requests back to the Direct and Manage Project Work process for implementation. The Direct and Manage Project Work process also produces the work performance data that is used by the Monitor and Control Project Work process to generate performance reports and more change requests. These and the change requests directly from stakeholders also must be processed though the Perform Integrated Change Control process. Moreover, directing and managing project work also generates deliverables, which, after verification and validation, become input to the Close Project or Phase process.

The lessons learned are the output of two processes: Manage Project Knowledge and Close Project or Phase. The lessons are learned throughout the project by performing the Manage Project Knowledge process, and not only at the end of the project or phase.

Road Ahead. This chapter together with the previous two chapters has presented the big picture of project management by exploring the project management framework and the environment in which the project is performed, as well as overviewing project management through all five stages of the project in terms of the integration management processes. As in many fields, in project management we measure progress or performance relative to baselines. In Part II of this book, we will meet two interrelated baselines—scope baseline and schedule baseline—while exploring the management of three important interrelated aspects of a project: scope, schedule, and resources.

Exam's Eye View

Comprehend

- Executing a project means implementing the project management plan developed during project planning.
- Directing and managing project work involves managing various technical and organizational interfaces in the project to facilitate smooth execution of the project work.
- The execution of the project is managed in an integrated way by performing the process called Direct and Manage Project Work, a high-level umbrella process for the executing stage, which generates the project deliverables.
- The two major output items of the Direct and Manage Project work process are project deliverables and work performance data, sometimes also wrongly called performance information.
- You monitor and control the project in an integrative way by using two processes: Monitor and Control Project Work and Perform Integrated Change Control.
- All the individual monitor and control processes, such as monitor risk, control quality, and control schedule, can generate change requests, which must be processed through the integrated change control process, in which each of these change requests will be deferred, rejected, or approved.
- Only the approved change requests should be implemented, i.e., processed, through the Direct and Manage Project Work process.
- You, the project manager, manage the project closure.
- Before going through project closure, the deliverables must be checked for their scope through the Validate Scope process and accepted by the customer or sponsor.

Look Out

- Two business documents, business case and benefit management plan, are the main input into developing the project charter, which acts as an interface or link between project objectives and the organization's strategic objectives.
- The change requests come from any monitor and change process or directly from stakeholders, but they must be processed through the Perform Integrated Change Control process.
- The performance reports, generated by the Monitor and Control Project Work process, are an input to the Perform Integrated Change Control process.
- Approved change requests must be implemented by performing the Direct and Manage Project Work process.
- The lessons learned are the output of two processes: Manage Project Knowledge and Close Project or Phase.
- The lessons are learned throughout the project by performing the Manage Project Knowledge process, and not only at the end of the project or phase.
- Not only the completed projects, but also the terminated projects, must be formally closed using the processes of the closing process group.
- The same process is used to close both a phase of a project and the project itself: Close Project or Phase.

Memorize

- The project charter is the document that formally authorizes a project, names a project manager with authority level, and identifies the project sponsor.
- All subsidiary project management plans, baselines, and some other documents are integrated into one plan called the project management plan. The rest of the documents used in a project are simply called project documents.
- The project management plan is an input to the all the integration management processes except two: Develop Project Charter and Develop Project Plan.
- Work performance data (sometime wrongly called work performance information) is an input to the Monitor and Control Project Work process.
- Change requests are an output of the Monitor and Control Project Work process and the Direct and Manage Project Work process, but they can also come from other monitor and control processes and directly from stakeholders.
- The Perform Integrated Change Control process is used to approve, reject, or postpone a change request.
- They are generated by the Direct and Manage Project Work process, verified through the Quality Control process, accepted by the customer through the Validate Scope process, and transitioned to the appropriate party through the Close Project or Phase process.
- The customer or project sponsor signs the final project outcome acceptance and closure documents.

Review Questions

1. Which of the following issues the project charter document?
   A. The sponsor or performing organization's higher management
   B. Any stakeholder
   C. The customer
   D. The project manager
2. What document is the result of the integration management process in the project initiation process group?
   A. Business case
   B. Project charter
   C. Project benefit management plan
   D. Preliminary scope statement

3. The project charter is important for which of the following reasons?

   A. It authorizes the sponsor.

   B. It names the project manager and authorizes the project manager to use the organization's resources for the project.

   C. It identifies all the stakeholders.

   D. It analyzes the stakeholders.

4. Which of the following is *not* included in the project charter?

   A. High-level risks

   B. High-level product requirements

   C. Budget summary

   D. Project schedule

5. You have been named the project manager for a project in your company codenamed *Kill the Bill*. The project must complete before Thanksgiving Day this year. This represents which of the following project characteristics?

   A. Assumption

   B. Constraint

   C. Schedule

   D. Risk

6. Which of the following is true about assumptions in project initiation?

   A. Because assumptions are a part of the project charter that you did not write, you don't need to validate them. Just assume the assumptions are true, and if the project fails, it's not your fault.

   B. Because assumptions represent risk, you must validate them at various stages of the project.

   C. An assumption is a condition that has been verified to be true, so you don't need to validate it.

   D. You must not start a project until all the assumptions have been proven to be true.

7. What is not true about the Manage Project Knowledge process?
   A. It generates the lessons learned register.
   B. It generates the lessons learned.
   C. It is performed at the end of project or phase.
   D. It uses project deliverables.
8. Every change request must be processed through which process?
   A. Perform Integrated Change Control
   B. Project charter and stakeholder register and Direct and Manage Project Work
   C. Monitor and Control Project Work
   D. Process Change Requests
9. The process or processes used to learn lessons from a project are:
   A. Manage Project Knowledge
   B. Direct and Manage Project Work
   C. Monitor and Control Project Work
   D. Close Project or Phase
10. Which of the following is not the output of directing and managing project work?
    A. Accepted deliverables
    B. Issue log
    C. Work performance data
    D. Change requests
11. The integrated change control process is used to manage changes to the project at which stage?
    A. From initiating through closing
    B. Planning only
    C. Executing only
    D. Monitoring and controlling only

12. A project manager is getting the risk-related recommended corrective actions approved. Which of the following processes is the project manager involved in?

    A. Perform Integrated Change Control

    B. No process

    C. Risk identification

    D. Monitor and Control Project Work

13. You have just received approval from the change control board to implement a few change requests. What process are you going to execute for that to happen?

    A. No process is needed

    B. Direct and Manage Project Work

    C. Perform Integrated Change Control

    D. Monitor and Control Project Work

14. Walking down the hallway, you heard a program manager saying to a project manager, "You need the performance reports to run this process." Which process might the program manager be referring to?

    A. Monitor and Control Project Work

    B. Perform Integrated Change Control

    C. Close Project or Phase

    D. Evaluate Performance

15. You heard a functional manager saying, "We are going to skip the closing stage. There is no need for formalities in this project; it's a total waste of time." For which kind of projects is it appropriate to skip the closing stage?

    A. Technical projects

    B. Small and simple projects

    C. Cancelled project

    D. No projects

16. Which of the following stakeholders can authorize the closure of a project?

    A. Project manager

    B. Customer

    C. Project sponsor

    D. Functional manager

17. You are preparing to close a project you have been managing. Which of the following is not an input to the Close Project or Phase process?

    A. Project charter

    B. Project management plan

    C. Project deliverables

    D. Project benefit management plan

PART

II

Scope, Schedule, and Resources

Congratulations! You have already seen the big picture of project management as described in Part I. You can't wait to begin executing. But hold on! I have a couple of questions for you. First, when you are executing your project, how will you know that you are on the right track? Second, during the execution, how will you know that the project is performing in such a way that it will end in success? The answer to both these questions is: baselines. You define your project in terms of baselines and measure its progress or performance by comparing the project result with baselines, and the deviations from the baselines measure how much the project is off track.

What will be done in the project and what will not be done define the project scope baseline. Work that needs to be done in order to implement this baseline needs to be scheduled. That gives rise to the schedule baseline, which then needs resources to implement it.

CHAPTER

4

Project Scope Management

The objectives covered in this chapter make up 9 percent of the exam, equivalent to about 12 questions. Study the whole chapter in detail.

It's enough to just remember the name of the input, tools and techniques, and outputs. You should know what is in a given input item that the given process uses and how that helps in generating the output, and what a given tool or technique does in a given process.

You should be very clear about the elements and their purposes inside each component of the scope baseline: scope statement, Work Breakdown Structure (WBS), and WBS dictionary.

While studying this knowledge area and its processes, pay attention to how the tasks can be tailored and adapted as needed, and recognize an agile environment in action; for example, continual assessment generates change requests which lead to changing plans—i.e., adapting.

P. Sanghera, *CAPM® in Depth*, https://doi.org/10.1007/978-1-4842-3664-2_4

CAPM Exam Objectives

Project Scope Management:

1. Understand the six project management processes in the project scope management knowledge area.
2. Identify the input, tools and techniques, and outputs defined in the six processes in project scope management.
3. Identify key concepts and tailoring consideration for project scope management and key roles in scope management.
4. Identify the purpose and elements of a Work Breakdown Structure (WBS) for both product and project scope.
5. Understand project scope management for agile/adaptive projects, including the use of prototypes.

After the project has been initiated, as discussed in the previous chapter, you need to develop a project management plan, which becomes the primary source of information for how the project at hand will be executed, monitored and controlled, and closed. The project plan development involves developing subsidiary plans, of which one important plan is the scope management plan. How important is the scope management plan? If a product is not in the scope, it will not and should not be produced. Before you start defining the scope, you need to know what the project and product requirements are. In other words, you need to collect requirements based on the needs and expectations of the stakeholders and in line with the project objectives. Once you have defined the scope based on these requirements, it needs to be broken down into concrete, manageable tasks that can be assigned and performed. This is accomplished through what is called the *work breakdown structure* (WBS).

Planning and controlling the project scope is crucial to the success of the project. Without it, the project can easily go off track. The primary purpose of project scope management is to ensure that the required work (and *only* the required work) is performed to complete the project successfully. If changes in the work requirements are made, they must be controlled—that is, the scope must be controlled. Also, before the outcome of the project is offered for acceptance, its scope must be validated with the customer or the sponsor; for example, to ensure the product has all the features that are promised in the scope statement.

In the preceding two paragraphs, we described project scope management in nutshell. So, the central issue in this chapter is managing the project scope. To be able to wrap your mind around this issue, you will explore three avenues: collecting requirements; defining project scope and creating WBS based on it; and verifying and controlling scope. Needless to say, all of this is done according to the plan; specifically, the scope management plan, in this case.

Managing Scope: Big Picture

The project scope is defined as the work that must be performed to deliver a product with a given scope. The product scope is the set of functions and features that characterize a product to be delivered by the project. The scope—i.e., product scope and project scope—refers to both what is included in the project and what is not. In other words, scoping a project means drawing boundaries around it. The importance of managing the project scope cannot be overemphasized, because it has a profound impact on the overall success of the project.

Caution! By *project scope* we usually mean the project product scope and the scope of the work required to produce that product. However, keep in mind that in PMBOK the project scope only refers to the work required to deliver the product, and does not include product scope.

STUDY CHECKPOINT 4.1

Among the following attributes, identify which are part of product scope and which are part of the project scope, according to PMBOK.

A. Develop software modules to support website.

B. The user can only access this website after logging in.

C. The drug should not have more than two side effects.

D. The drug must be developed within one year.

E. The drug must be tested in-house before it goes to the Food and Drug Administration.

The major goal of scope management is to ensure that the required work and *only* the required work is included and performed in the project. As shown in Figure 4-1, this goal is accomplished by the following functions of project management:

- **Plan Scope Management.** This process is performed to develop a document called the scope management plan, which contains information on how to define, control, and validate the scope; i.e., the project and product scope.
- **Collect Requirements.** This is the process performed to collect, determine, and document the project and product requirements and plan to manage those requirements.

- **Define Scope.** This process is performed to develop a detailed description of the project and the product in the sense of what is included and what is not.
- **Create Work Breakdown Structure (WBS).** This process is used to develop the work breakdown structure in which deliverables, and hence work to produce them, are broken down into smaller manageable tasks that can be assigned to team members. This is done starting with the scope.
- **Validate Scope.** This is the process used to formalize the acceptance of the completed and already verified project deliverables.
- **Control Scope.** Used to monitor the status of the scope—i.e., project scope and product scope—and to manage changes to the scope baseline.

Figure 4-1 illustrates the high-level view of the logical connections between these processes. More high-level information about these processes is presented in Table 4-1.

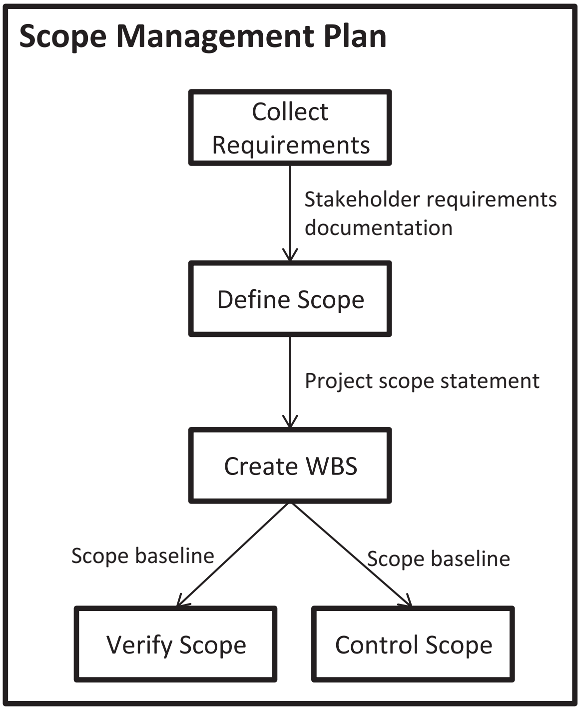

Figure 4-1. A high-level view of interactions and data flow between different components of scope management. All processes are performed according to the scope management plan.

Table 4-1. Processes of Scope Management Mapped to the Process Groups

Scope Management Process	Process Group	Major Output	Performed
Plan scope management	Planning	Scope management plan, requirement management plan	Once or at predefined project points
Collect Requirements	Planning	Requirement documentation, Requirement traceability matrices	Once or at predefined project points
Define Scope	Planning	Project scope statement	Iteratively
Create WBS	Planning	Scope baseline	At predefined project points
Control Scope	Monitoring and Controlling	Work performance information	Throughout the project
Validate Scope	Monitoring and Controlling	Accepted deliverables, work performance information, change requests	As needed

Before we can manage the scope, we need to develop the scope management plan.

Developing the Project Scope Management Plan

Before performing the five scope management processes, you must develop the scope management plan, a blueprint that will show how to develop, control, and validate the scope. As mentioned previously, this plan is developed using the Plan Scope Management process, illustrated in Table 4-2.

Table 4-2. The Plan Scope Management: Input, Tools and Techniques, and Output

Input	Tools & Techniques	Output
1. Project charter	1. Expert judgment	1. Scope management plan
2. Project management plan	2. Alternative analysis	2. Requirement management plan
3. Enterprise environmental factors	3. Meetings	
4. Organizational process assets		

You must develop this plan in the context of the purpose of the project, which is documented in the project charter, where you will also find a high-level project description and high-level requirements along with other relevant information, such as assumptions and constraints. Also, you will need

the project management plan in the input for the quality management plan, details of the project lifecycle, and a development approach. All three will impact how you plan the scope management. Development approach refers to the development approach or approaches adapted for this project, such as agile, waterfalls, or iterative. The plan scope management process will also be influenced by EEFs (Enterprise Environmental Factors) like personnel administration, culture, and infrastructure of the organization, along with marketing conditions. Of course, speaking of OPAs (Organizational Process Assets), this plan will be developed by following the organizational policies and procedures, and you will make use of historical information, including lessons learned from past projects.

As far as tools are concerned, in the process of developing a scope management plan you will use expert judgment on relevant topics and meetings with the appropriate stakeholders, such as project sponsor and some project team members. We also want to explore various techniques that can be used to collect requirements, define and elaborate scope from the requirements, and validate the scope on the finished product—the alternative analysis. Of course, another data analysis method could also be considered to accomplish the same goal.

As a result of applying these tools on the input, we get the scope management plan and the requirement management plan, described next.

Requirement Management Plan and Scope Management Plan

The requirement management plan basically describes the collect requirements process: how to collect, determine, and document the project and product requirements and plan to manage those requirements. It addresses questions like the following:

- How does one prioritize requirements?
- What kind of metrics will be used and why?
- How does one plan, track, and report requirement-related activities?
- How will the changes will be traced, initiated, tracked, and their impact by analyzed?

Similarly, the scope management plan describes the "how to" details regarding the rest of the scope management processes: define scope, create work breakdown structure, control scope, and validate scope.

Before you can actually define and develop the scope, you need to have a very crucial item in place: stakeholder requirements, which form the basis of the scope.

Caution! It's important to realize that product scope and project scope are not independent. Product scope is the set of functions and features that fully define the product, and project scope is the work required to deliver the product. So, the product scope more or less determines the project scope.

The project scope management plan and requirement management plan become part of the project management plan.

Collecting Requirements for the Project

The project success is defined as the delivery of the planned outcome with full scope, on time, and within the schedule. To realize this success, it's very important that there is an agreement on what exactly is being delivered with what requirements. A requirement is a condition, characteristic, or capability that a specific outcome of the project must have. For example, an online banking website is an outcome of the project, and the condition that it must record the number of users that visit the site each day is a requirement, as is that the user login must be secure. Requirements may come from different sources, such as from standards, specifications, and contracts. Stakeholder expectations and needs within the context of the project objectives materialize into requirements.

Note Generally speaking, project requirements should include the product requirements. However, many organizations distinguish between project requirements and product requirements, in which case project requirements include strictly project-related requirements, such as schedule and delivery requirements, business-related requirements, and other project management requirements, whereas product requirements include the product-related requirements, such as requirements related to product performance, security, and defects.

You need to do some requirements planning, which includes:

- Defining and documenting the project requirements
- Defining and documenting the product requirements
- Managing the requirements throughout the project

Tip How effective you are in capturing requirements will determine how effective you are in getting agreement on these requirements from the stakeholders and in managing the stakeholders' expectations and needs. Also, these requirements go right into the foundations of the WBS, along with the deliverables. Therefore, collecting requirements effectively is critical for the success of the project.

You collect requirements by using the Collect Requirements process, illustrated in Table 4-3 in terms of input, tools and techniques, and output. Input includes all the relevant documents—i.e., plans and project documents and business documents—where you can get all the high-level information regarding project and product requirements. Based on the information provided so far in this book, you can easily guess that these documents are:

1. Business document: business case
2. Project charter
3. Agreements
4. Plan documents: Requirement management plan and scope management plan, covered in the previous section, and the stakeholder engagement plan, which will be useful in managing the requirements.
5. Project document: Assumptions log for assumptions about project, product, stakeholders, etc.; the lessons learned register for information on which requirement-collection techniques have been effective so far; and stakeholder register, which provides information about stakeholders and requirements.

Table 4-3. The Collect Requirements Process: Input, Tools and Techniques, and Output

Input	Tools & Techniques	Output
1. Project charter	1. Expert judgment	1. Requirement documentation
2. Project management plan	2. Data gathering	2. Requirement traceability matrix
3. Business documents	3. Data presentation and analysis	
4. Agreements	4. Prototyping	
5. Enterprise environmental factors	5. Context diagrams	
6. Organizational process assets	6. Decision making	
	7. Interpersonal and team skills	

The stakeholder engagement plan and stakeholder register will be covered in an upcoming chapter on stakeholder management.

Of course there are some EEFs and OPAs that influence the requirement collection process. This is left as an exercise for you in Study Checkpoint 4.2. Just ask yourself what factors and assets can be the source of requirements or can help you reach them.

STUDY CHECKPOINT 4.2

Make lists of enterprise environment factors and organizational process assets that can influence the Collect Requirements process.

So, these input items provide us with the high-level requirements and high-level project and product information from which requirements may be drawn. Next, we need to analyze these requirements and information by using some tools and techniques to do the following:

1. Extract the final refined set of requirements.
2. Manage them.

Tools and Techniques for Collecting Requirements

You collect the requirement-related data, present it, analyze it, and make decisions about requirements or tools. You perform these tasks by using some techniques. If you need help with these techniques, you can always use tools of expert judgment.

Data-Gathering Techniques

The following are some examples of data-gathering techniques that can be used depending on the project need.

Observation and Conversation. Observation is a technique in which the requirements about a product or project process are gathered by directly observing the user using the product or performing the process. In other words, the process or product is observed in action in the real world with people on the job. For that reason, this technique is also called *job shadowing*. Depending on the situation, the observer can simply observe the user doing the job or can participate in it. Of course, conversation and articulation skills will matter here.

Interviews, Questionnaires, and Surveys. An interview is typically performed by asking pre-determined and on-the-spot questions and recording the responses. Depending on the situation, interviews may take several forms, such as one-on-one, multiple interviewees, or multiple interviewers. For example, by interviewing subject matter experts and individuals who ran similar projects before, you may identify and define some features and functions of the project deliverables.

When you want to cover a large number of respondents quickly, questionnaires and surveys will be more appropriate. These are based on a written set of questions.

Focus Groups and Facilitated Workshops. A focus group is a set of prequalified stakeholders and subject matter experts that are brought together with the purpose of learning about their opinions, expectations, and attitudes about a product, service, or result that will be the output of the project. Generally speaking, a moderator facilitates the interactive discussion to make this experience more conversational than one-on-one interviews.

A facilitated workshop is a session that brings together cross-functional stakeholders to focus on defining product requirements. It generally proves to be an effective technique for quickly defining cross-functional requirements and reconciling differences among the stakeholders regarding the requirements. These workshops also help in developing trust and improving communication among the stakeholders, therefore fostering relationships that could help the project to succeed.

Benchmarking. Benchmarking is comparing practices, products, or services of a project with those of some reference projects for the purpose of learning, improving, and creating the basis for measuring performance. We will learn more about it an upcoming chapter on quality management.

Brainstorming. This is a creative technique generally used in a group environment to gather ideas as candidates for a solution to a problem or an issue without any immediate evaluation of these ideas. The evaluation and analysis of these ideas happens later. Obviously, this technique can also be used to collect requirements.

Data-Presentation and -Analysis Techniques

When you have requirement-related data, it needs to be presented for review and analysis. Various data-presentation techniques may be used, some of which will be discussed next.

Affinity Diagram. This is a technique in which a large number of ideas or data are classified into different groups using some criteria. Then, the relationships among these ideas are explored. This facilitates an effective and efficient review and analysis.

Idea/Mind Mapping. This is a visual technique in which various ideas, such as those collected through brainstorming, are mapped around a central or key concept in order to expose commonalities and differences among them. In this way, one can understand the existing ideas better, consolidate them, and generate new ideas. Mapping also helps when classifying ideas into groups by discovering relationships among them. In addition to project management, this technique is also used in other areas, such as personal, family, and education. It helps in summarizing, clarifying, and revising ideas.

Nominal Group Technique. This technique combines brainstorming with discussion and ranking ideas by voting or scoring. Here are the steps:

1. For a given problem, a group member creates her/his own ideas in private.
2. A moderator presents all ideas anonymously in one place to the group.
3. All presented ideas are discussed to better understand them.
4. Each member scores each idea privately on a scale, e.g.; from 1 to 5.

Higher-ranking ideas can be processed again through these steps. At the end, the best-ranked idea or ideas are selected.

These techniques can be used to prioritize the requirements.

Also, different data-analysis techniques can be used, such as document analysis, which involves accessing the relevant documents, studying them, and extracting the relevant information, in this case the requirements, from them. In this process, the relevant document is any document with requirement-related information, such as project product marketing material, agreements, business plan, and request for proposals.

Prototyping

A prototype is a working model of a product put together without developing the actual product, such as a small-scale or toy product, mock-ups, computer-generated models, and computer simulations, e.g.; Monte Carlo simulation. Organizations usually make prototypes when developing a proof of concept. Prototypes can also be used to collect requirements by experimenting with the prototype and letting stakeholders experiment with it and offer feedback. It's more tangible than the abstract idea of a product. Prototypes can be improved and modified based on the feedback from the stakeholders. In this way, prototypes support the progressive elaboration process of developing requirements.

Context Diagrams

A context diagram is a very useful tool for determining the requirements of a product, as it presents the product scope visually by showing how the business system is used. In other words, a typical context diagram shows two kinds of components: parts of the system that users can access, and users, also called actors. Actors play two kinds of roles: entering the input into the system and receiving the output from the system. One actor can play one or both roles. Figure 4-2 presents a very simple example of a context diagram of an online learning system, where arrow direction shows which way the information flows.

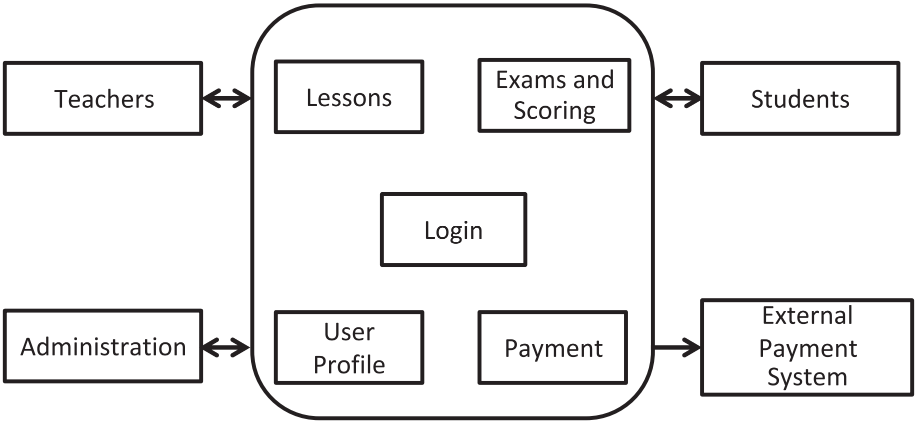

Figure 4-2. Context diagram of an online learning system

STUDY CHECKPOINT 4.3

Assuming that the online learning system in Figure 4-2 is managed by a company with its own teachers:

Q1. Name internal actors

Q2. Name external actors

Decision-making Techniques

Decision making is, in general, a process used to collectively assess and evaluate multiple alternatives in terms of expected outcomes. The decision usually results in taking specific action. In this process, you will need to make decisions—e.g.; identify/generate, classify, and prioritize project and product requirements. There are multiple methods available to make decisions that were discussed in Chapter 3.

Interpersonal and Team Skills

In applying the data-collection techniques, interpersonal and team skills will be needed, such as conversational and articulation skills, running facilitation works, and using nominal group techniques. All these techniques are discussed in the sections on data gathering, presentation, and analysis.

You use one or more of these techniques on the input to generate the output of the Collect Requirements process.

Output of Collecting Requirements

During the process of collecting the requirements, you will produce two documents: stakeholder requirements document and requirements management plan.

Requirement Documentation

This documentation consists of a list of requirements and any necessary details for each item in the list. The details of the requirements and the format of the document depend on the project and the rules within the performing organization. The following are some essential elements of the requirement document.

For effective management, you can organize the requirements into different categories.

Business Requirements. It describes the business need for which the process was started; e.g.; the overall purpose of the project, such as the opportunity being seized or the business problem being solved.

Project Requirements. These are about the project-related processes, needs, and conditions, such as milestone data and other conditions in the contract.

Solution Requirements. These are of two types: 1) functional requirements, referring to the functionality of the project outcome—e.g.; what the product does, its feature; and 2) non-functional requirements, such as compliance, compatibility, support, reliability, safety, and performance.

Stakeholder Requirements are based on the needs of all or part of the stakeholders.

Quality Requirements such as not allowing more than three bugs per software module.

Support and Training Requirements such as the product will be released with a manual.

Impact of the Requirements. This element describes the impact of requirements on the project and on entities external to the project, such as different groups in the organization.

Some requirements will start out vague due to a lack of detailed information, but will progressively become more well defined as more detailed information become available.

Caution! The final version of each requirement must be well defined and not vague. As a test, always ask this question: how will I be able to measure or test it? Only then it can be used for baselining. Also, make sure that a requirement is consistent within itself and with other requirements.

Requirements are usually traced and tracked using a tool called the requirements traceability matrix.

RequirementsTraceability Matrix. As the name suggests, the requirements traceability matrix is a table that traces each requirement back to its origin, such as product or business objective, and tracks its progress throughout the project lifecycle. Linking a requirement to the business objective underlines its value. Tracking the requirement throughout the lifecycle of the project ensures that it will be delivered before the project is completed. So, this table becomes a very useful tool to remind the team how important these requirements are, when they are going to be implemented, and how we are progressing in implementing them. The requirements traceability matrix links each requirement to, for example,

- business need, opportunity, and objective;
- project objectives and deliverables;
- the project scope and the product scope and deliverable;
- the product design, development, and testing; and,
- for high-level requirements, to their details.

Key information about a requirement can be stored in the form of its attributes, such as a unique identifier, description, owner, source, priority, status, and completion date.

The requirements become the basis on which you develop the scope.

Defining the Project Scope

The project charter is developed during the initiation stage of the project. As you move to the planning stage, during the development of the scope management plan and the requirement document, also called requirement documentation, you have enough information about the project and the product to start defining the project scope.

Note When we say *scope* or *project scope* it generally includes both the scope of the project and the scope of the product that it will deliver unless stated otherwise.

The scope is defined by using the Define Scope process illustrated in Table 4-4.

Table 4-4. Define Scope: Input, Tools and Techniques, and Output

Input	Tools & Techniques	Output
1. Project charter 2. Scope management plan 3. Project documents 4. Enterprise environmental factors 5. Organizational process assets	1. Expert judgment 2. Data and product analysis 3. Decision making 4. Interpersonal and team skills	1. Project scope statement 2. Project document updates

Input to Scope Definition

The purpose of the Define Scope process is to figure out the detailed descriptions of the project and its product. Therefore, the following documents are the obvious input to this process.

- **Project Charter.** This is needed for high-level project and product descriptions and approval requirements.
- **Scope Management Plan.** This is needed for information on how the scope will be defined.
- **Project Documents**. These include requirement documentation, assumptions log, and risk register.

Here are some examples of the organizational process assets that can be helpful in defining the scope:

- Template for project scope statement
- Scope-related project files from the previous projects

- Lessons learned from previous projects or from previous phases of this project
- Policies and procedures relevant to defining the project scope

This process will be influenced by almost the same enterprise environment factors as in the case of the Collect Requirements process.

Tip It's critical to the success of the project that you determine the scope correctly—only the required features and functions for the product and only the required work to produce those features and functions; nothing less, nothing more.

Once you have input for the scope definition, you apply the tools and techniques discussed next to define (or redefine) the project scope.

Tools and Techniques for Scope Definition

This section will discuss the tools and techniques used in the scope definition process.

Expert Judgment. You can use help from relevant experts in the organization to develop parts of the detailed project scope.

Product Analysis. To hammer out the details of the product scope, you might need to perform product analysis, which can include techniques such as product breakdown, requirement analysis, system analysis, system engineering, value analysis, and value engineering. The goal is to translate the project objectives into tangible deliverables that meet the requirements. Each application area has different product-analysis methods to accomplish this.

Data Analysis. Scope includes both product description and the kind of project work needed to deliver that product. Analysis is performed to find the best approaches to defining and performing project work. One such analysis technique is alternatives analysis, which can be used to evaluate the different methods for implementing the requirements to help one pick the best one.

Decision-making Techniques. One or more of these techniques, described in Chapter 3, such as multicriteria, can be used to set criteria for requirements, schedule, cost, resources, and so forth. The goal here would be to explore and refine the scope.

Interpersonal and Team Skills. Of course, in the business of project management, you often use these skills. In this process, for example, you would use facilitation skills in facilitated workshops with stakeholders.

You apply these tools or techniques to the input to hammer out the output of the scope definition process.

Output of Scope Definition

Depending on the input, the scope definition process can generate two kinds of output: the project scope statement, which contains the original scope definition, and approved updates to some project documents. Recall that the project scope statement is a component of the baseline used to manage change requests to the project.

Caution! The project scope statement contains both the project scope and the project product scope.

Project Scope Statement

The key output item of the Define Project process is the project scope statement, which includes the project scope as well as the product scope. It basically describes what needs to be accomplished by the project: product and work to generate the product. It provides a documented basis for the following:

- Developing a common understanding among the stakeholders about the project scope
- Doing detailed planning
- Creating WBS

The specific elements that may be included in the project scope statement are discussed in the following list:

- **Product Scope Description.** Product scope is defined as description of features, functions, and other characteristics a project product.
- **Product Acceptance Criteria.** This defines the process, criteria, and conditions for accepting the completed products that the project will deliver.

- **Project Assumptions and Constraints.** Assumptions and constraints are initially included in the project charter. However, at this stage, you have more information about the project and therefore can revisit the initial assumptions and constraints; you might be able to identify more assumptions and constraints. You should document the specific assumptions related to the project scope and also analyze their impact in case they turn out to be false. Due to the uncertainty built into them, assumptions are potential sources of risk.

  Constraints related to the project scope must also be documented in the scope statement. Because constraints limit the team's options, the constraints' impact on the project must be evaluated. The constraints can come from various sources, such as a predetermined deadline (also called *hard deadline*) for the completion of the project or a milestone, limits on the funds available for the project, and contractual provisions.

- **Project Deliverables.** A deliverable is a unique and verifiable project outcome, such as a product, a capability to provide a service, or a result. It may be required to be produced to complete a project, a process, or a phase of the project. The deliverables may also include related material, such as manuals and other documentation. The scope statement provides the list of deliverables and their descriptions.

- **Project Exclusions.** This involves drawing boundaries around the project by specifying what is included and what is not, especially focusing on the gray areas where stakeholders may make their own assumptions, different from each other's. It generally identifies what is excluded from the project, which helps to manage stakeholder expectations.

Tip You must be able to make a distinction between objectives, deliverables, and requirements. For example, in a project to launch a website, the site is a deliverable. That the site must print a warning message at the login time is a requirement, and that the site should increase the company revenue by 3 percent is an objective.

The project scope statement serves the following purposes:

- It serves as a component of the baseline that will be used to evaluate whether a request for a change or additional work falls within or beyond the scope of the project; hence, helps with avoiding scope creep.
- In general, it helps with making project decisions throughout the lifecycle of the project.
- By providing a common understanding of the project scope, the scope statement helps bring the stakeholders onto the same page in their expectations.
- Because the scope statement describes the deliverables and the work required to create those deliverables, it is used to create a WBS, which helps in scheduling the project.
- It serves as a guide for the project team to do more-detailed planning.

As a result of this process, some documents would need to be updated.

Project Document Updates

In the process of defining the project scope, you may end up modifying the existing requirements or adding new requirements. You may also learn more about the stakeholders. Also, some assumptions may no longer be true. Accordingly, the documents that may be updated as a result of defining the scope include the following:

- Requirement documentation
- Requirement traceability matrix
- Stakeholder register
- Assumptions log
- Stakeholder register

STUDY CHECKPOINT 4.4

In the following table, match each item in the first column with an appropriate item in the second column:

A. The software product must run on both Microsoft Windows and Apple Macintosh.	1. Project deliverable
B. An online education website	2. Project constraint
C. The drug must be developed within six months.	3. Product requirement
D. The software module must not have more than 10 bugs.	4. Project management requirement
E. Project manager must have a PMP certification.	5. Product acceptance criteria

In a nutshell, the project scope statement specifies the scope of the project in terms of the project outcome specified by its characteristics and the way it would be produced and delivered by the project. From the perspective of actually performing the work, the scope statement is still a high-level document. To be able to schedule the project, identify and assign resources, and manage the project successfully, these deliverables need to be broken down into manageable tasks. This is accomplished by creating an entity called the work breakdown structure (WBS).

Caution In defining scope, we don't use all the requirements that were collected; instead, we consider only those that made it to requirement documentation after analysis.

Creating a Work Breakdown Structure (WBS)

What is the secret behind accomplishing seemingly impossible tasks in any field? The answer is to break down the required work into smaller, manageable pieces. This is also a very important process in project management. To be able to actually execute the project, the project scope is broken down into manageable tasks, thereby creating a work breakdown structure (WBS). In other words, a WBS is a deliverable-oriented hierarchy of the work that must be performed to accomplish the objectives of and create the deliverables for the project.

Table 4-5 shows the input, tools and techniques, and output of creating the WBS. The project scope statement contains the list of deliverables and product description. The requirement documentation describes the product and project requirements. Information in these two items provides the basis for creating WBS, and scope management tells us the "hows" of developing the WBS.

Table 4-5. The Create WBS Process: Input, Tools and Techniques, and Output

Input	Tools & Techniques	Output
1. Scope management plan	1. Expert judgment	1. Scope baseline
2. Project documents: project scope statement, requirement documentation	2. Decomposition	2. Project document updates
3. Enterprise environmental factors		
4. Organizational process assets		

You should always consider organizational process assets while going through this and several other processes. You can, for almost any process, close your eyes and see the relevant organizational policies and procedure, relevant templates, and relevant project files and lessons learned from previous projects. In this case, *relevant* means related to WBS. Depending on the application field or specific industry of your project, there may be industry standards for creating WBS. That standard is an example of an EEF for this process.

You can always make use of expert judgment on topics relevant to the process, but the main technique that you will need to create the WBS is decomposition.

Decomposition

Decomposition is a technique for subdividing the project deliverables into smaller, manageable tasks called *work packages*. The WBS is a hierarchical structure of an inverted tree with work packages at the lowest level of each branch, the leaves. A level can be broken down into sublevels. The depth or height of the tree or decomposition depends on the size and complexity of the project. Different deliverables may have different levels of decomposition, as shown in Figure 4-3, a simple example of WBS, where the lines are called branches and the boxes are called nodes or packages; the lowest packages are called work packages.

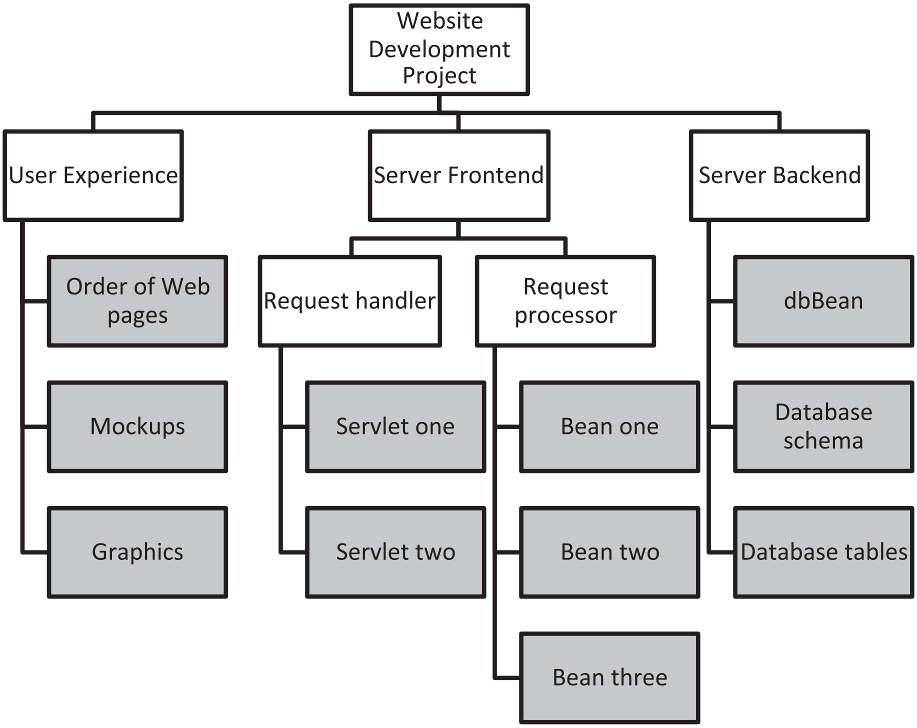

Figure 4-3. An example of WBS. The work packages are represented by the dark boxes at the end of each branch. Servlet and Bean refer to the programs that will need to be developed.

You decompose the scope by executing the following steps:

1. Identify the deliverables and the work involved by analyzing the project scope statement and requirement documentation.
2. Understand the relationships among the deliverables.
3. Structure and organize the first level (just below the root of the hierarchical tree) of the WBS hierarchy. Based on the project at hand, you can use one of the following approaches; e.g.; use the deliverables as the components in the first level or use the phases of the project as the components in the first level.
4. Decompose the upper level into more-detailed components for the lower level.
5. Keep decomposing to lower levels until necessary and sufficient decomposition has been achieved.
6. Assign identification codes to the WBS components.

As the work is decomposed to lower levels of detail, work components become more concrete and manageable. However, you should avoid excessive decomposition because it will lead to a large number of work packages, and it will not be possible to manage all of them effectively. In other words, excessive decomposition leads to inefficient use of management and other resources. Necessary and sufficient decomposition is the key.

Tip During decomposition, the components are defined in terms of how the project work will actually be executed and controlled. You must verify the correctness of the decomposition at each level by requiring that the lower-level components are necessary and sufficient to the completion of the corresponding higher-level deliverables.

While using the technique of decomposition, remember a useful concept or trick: *rolling wave planning*. It's a fancy term that refers to handling a deliverable or its subcomponent that cannot be decomposed further currently because we don't know the details about it yet; for example, it is to be executed far in the future. We leave the decomposition of such a deliverable at a level allowed by the available information and wait on further decomposition until more information becomes available. Yes, it is an example of progressive elaboration.

The WBS document is the key item of the Create WBS process, but there are some other output items as well.

Output of Creating WBS

During the Create WBS process and when putting together the scope baseline, and the main output of the create and we may discover that the content of some document needs to be updated; e.g.; assumptions and constraints in the assumptions log and requirements in requirement documentation.

Scope Baseline

The main output of the Create WBS process, scope baseline, consists of the project scope statement, WBS, and WBS dictionary. These components of the scope baseline are discussed next.

Project Scope Statement. This document includes project and product scope description, project deliverables, product acceptance criteria, and project assumptions and constraints.

Work Breakdown Structure. As explained earlier, the WBS is a deliverable-oriented hierarchical structure that decomposes the project scope and deliverables into the work packages that will be executed by the project team to create the planned deliverables and in this way accomplish the planned project objectives. The project manager creates this document with the help of the project team.

Work Packages and Control Account. Remember, at the lowest part of each branch in WBS we have work packages, each of which is assigned a unique identifier. To this identifier is attached information about schedule, resources, and cost for this work package, and it acts as a code of account. In other words, each work package represents a deliverable or a component of it, with schedule, resources, and cost attached. Using one or more such points or codes of account, information on schedule, resources, and cost for a group of work packages can be summed or integrated and managed. This way, each package control point becomes a part of what is called the control account for that group of work packages. A control account represents a control management point where scope, schedule, and cost are integrated for the purpose of monitoring and controlling the performance; e.g.; comparing with earned value.

Caution A control account may contain one or more work packages, but a work package can have membership in only one control account. This means that a control account is in some package above the work packages and contains all the work packages below it in the branch to which it belongs.

A control account may include one or more planning packages.

Planning Package. This is a WBS component or package used for planning one or more work packages. Obviously, it should be below the control account package to which it belongs and above the work packages that it's going to plan.

WBS Dictionary. This is a supporting document for the main WBS document to provide details about the components of the WBS. The details about a component might include elements such as a code of account identifier, description of work involved, quality requirements, acceptance criteria, list of milestones schedule, cost estimates, required resources, contract information, if any, and the organization or group responsible for this component.

Tip As you can guess, most of the information in the WBS dictionary is generated by other processes.

Note Do not confuse the WBS with other information breakdown structures, such as the organizational breakdown structure (OBS), which provides a hierarchy of the performing organization and can be used to identify organizational units for assigning the WBS work packages. Remember, the end goal of the WBS is to specify the project scope in terms of work packages; this is what distinguishes the WBS from other information breakdown structures.

Caution! The PMP exam expects you to know the ropes around the formal standard terminology. For example, if I say project plan, you should be able to figure out that I'm referring to project management plan. Another example: If I say "defining scope," you should be able to translate it to the Define Scope process, the same way you will translate the planning stage to the Planning process group.

STUDY CHECKPOINT 4.5

Q1. What is the difference between management control point and control account?

Q2. What is the difference between control account and code of account?

The mantra before developing the WBS is as follows: If it's not in the WBS it will not be done. The mantra after developing WBS should be: If it's not in the scope baseline it will not be done.

The approved version of the scope baseline becomes a component of the project management plan and can be changed only through the formal change control procedure, i.e., running the processes. It plays a crucial role in determining many aspects of the project, such as schedule, cost, quality, and procurement. In other words, it's very important that scope is monitored and controlled.

Controlling Scope

Controlling the project scope is all about keeping a tab on the status of the project scope and product scope as well as managing changes to the scope baseline. While controlling the scope, you focus on the following tasks:

- Watch out for scope creep. Determine whether it has happened and correct the situation. Scope creep refers to scope changes applied without processing them though the change control process.

- Process the scope change requests through the integrated change control process for approval.
- Manage the implementation of scope changes after approval, as well as their impact across the project.

Tip In real life, scope creeps occur for various reasons. For example, perhaps a development engineer thought something was a cool feature to implement, or the customer spoke directly with the engineer to make a request for a minor additional feature, or various other similar situations. If a scope creep has taken your project off track by affecting schedule, resources, cost, and so on, you need to take corrective action to get the project back on course. You should also investigate how the scope creep happened and take steps to prevent it in the future—for example, by educating team members about the proper scope change process.

Given the input, tools and techniques, and output in Table 4-6 for this process, the following is a brief account of how the output is generated from the input by using tools and techniques:

1. *Scope baseline* contains the WBS and the WBS dictionary and tells us what the approved scope is. We have the *scope management plan* to tell us how to control the scope.
2. Compare the actual *work performance data* with the *performance measurement baseline* by using the variance analysis.
3. Compare the scope aspect of the *work performance data* with the *scope baseline* by using variance analysis.
4. Use the trend analysis tool on project performance over time to determine if it's improving or getting worse.
5. Steps 2, 3, and 4 will generate two main output items:
    a. Work performance information that includes how the actual project scope performance is progressing compared to the scope baseline.
    b. This comparison may generate change requests to bring the project on track; e.g.; request to change scope, schedule, or cost baselines.

6. We will manage these changes using the *change management plan* and *configuration management plan* discussed in previous chapters.
7. Use *requirement documentation* to detect any requirement-related deviation from the scope baseline and use the *requirement traceability matrix* to link the impact of any change to project objectives.
8. As in the previous chapter, all change requests are processed through the integrated change control process for approval, and only approved changes are implemented by using the Direct and Manage Project Work process.
9. In the Control Scope process (see Table 4-2), the input item *work performance data* includes information about received, approved, implemented, and validated change requests. Change requests generated in this process will require updating some documents, such as the following:
    a. *Scope baseline* for scope change, and *scope management plan* to record how to manage those changes.
    b. *Schedule baseline, cost baseline, and performance measurement baseline* because changes in scope baseline or any of these baselines may trigger changes in the rest of the baselines in this set of baselines.
    c. In addition to these plan document updates, some project documents may also need to be updated, including *lessons learned register* with effective scope control techniques, *requirement documentation* with additional, changed, and removed requirements, and *requirement traceability matrix* to make it consistent with requirement documentation.

Table 4-6. The Control Scope Process: Input, Tools and Techniques, and Output

Input	Tools and Techniques	Output
1. Project Management Plan: • Scope baseline • Performance baseline • Scope management plan • Requirement management plan • Change management plan • Configuration management plan 2. Work performance data 3. Project documents • Requirement documentation • Requirement traceability matrix • Lessons learned register 4. Organizational project assets	1. Data analysis: • Variance analysis • Trend analysis	1. Work performance information 2. Change requests 3. Project management plan updates: • Scope management plan • Baselines: Scope, schedule, cost, and performance measurement. 4. Project document updates: • Requirement documentation • Requirement traceability matrix • Lessons learned register

STUDY CHECKPOINT 4.6

Q1. List some of the organizational process assets that will influence the Control Scope process.

Q2. Why do you need a lessons learned register in the input of the Control Scope process?

The scope monitoring and controlling ends with validating scope for acceptance of project deliverables.

Validating the Scope of Project Deliverables

Validating scope is the process of formally accepting the completed project deliverables, which have already been verified for their correctness by using the control quality process. Before you hand over the project deliverables to the appropriate party mentioned in the project management plan, such as the customer or the sponsor, you need to validate with the party that the deliverables actually meet the planned scope.

Caution! You should perform the Validate Scope process with the appropriate party even if the project is terminated; that is, ended before completion. In that case, you would verify and document the level and extent of the project and product scope that was completed. At the very least, it will help the close project process; e.g.; for the record, project review, and lessons learned.

Validating the scope of the project deliverables includes inspection, also called audits, product review, and walkthrough, depending on project and organization. The purpose is to ensure that all deliverables are completed as planned and therefore as expected.

The process used in validating the scope is formally called Validate Scope, and its input, tools and techniques, and output are given in Table 4-7. It may be described in terms of the following steps.

1. Use the *scope management plan* to find out the planned procedure of accepting the deliverables.
2. Study the *quality reports* about *verified deliverables* to find issues and recommendations. Also, information in the *lessons learned register* can be used to improve the validation procedure in terms of efficiency and effectiveness.
3. Compare the requirements in the *requirement documentation* with the actual *work performance data,* which contains information on how much the actual work complies with the planned requirements.
4. Use *requirement management plan* and *requirement traceability matrix* for information on how validate to the requirements.
5. Also, compare the actual result to the *scope baseline*.
6. Deviations and non-compliance found in steps 2, 3, and 4 may generate change requests such as requests for defect repairs as an output.
7. Of course, in steps 2, 3, and 4 you were using an inspection technique that also creates the output item called *work performance information*, which records validation status information such as which deliverables have been accepted and which have not, and why.

8. Validated deliverables form the output item *accepted deliverables* and are handed over to the appropriate party, such as the customer or the sponsor, after being signed off by them.

9. Update the affected documents such as requirement documentation and requirement traceability; see checkpoint 4.7.

Table 4-7. The Validate Scope Process: Input, Tools and Techniques, and Output

Input	Tools and Techniques	Output
1. Verified deliverables 2. Work performance data 3. Project Management Plan: • Scope baseline • Scope management plan • Requirement management plan 4. Project documents: • Requirement documentation • Requirement traceability matrix • Lessons learned register • Quality reports	1. Decision making 2. Inspection	1. Accepted deliverables 2. Work performance information 3. Change requests 4. Project document updates: • Requirement documentation • Requirement traceability matrix • Lessons learned register

Caution! Do not confuse scope validation with quality control or scope verification performed using quality control, which is primarily focused on checking the correctness of the deliverables and other quality requirements; scope validation is about ensuring that the entire scope with the requirements with have implicated.

STUDY CHECKPOINT 4.7

Q1. The project scope statement, WBS, and WBS dictionary are used to validate scope. Where are they in Table 4-5?

Q2. The Verify Scope process belongs to which process group?

Q3. From Table 4-5, you know that project documents requirement documentation, requirement traceability matrix, and lessons learned register are updated during the Validate Scope process. Using your knowledge about these documents, what do you think they are updated with in the process?

Q4. Which process will be performed first: quality control or validate scope?

The three most important takeaways from this chapter are as follows:

1. Requirements are the basis on which we develop the scope that leads to WBS, the work required, which requires a schedule and determines cost. That way, requirements play a crucial role in determining the schedule, cost, quality, and procurement.
2. The project scope statement consists of both project scope and product scope. The WBS, WBS dictionary, and project scope statement constitute the scope baseline, an output of the Create WBS process, against which the actual work results are compared.
3. To avoid scope creep and to ensure that the scope is implemented, you need to control the scope. Also, the scope of the project outcome needs to be validated before the acceptance of verified product.

Summary

Project scope management includes processes that are used to ensure that the project includes all the required—and only the required—work. They ensure the work is done in a certain way, i.e., with a schedule, to deliver a product with certain characteristics. Of course, you need to plan this work and its way, and also the product characteristics. So, what we are talking about here is called scope management. It contains planning processes that end up in an established scope baseline against which the actual work results are measured. To control the planned scope, and to ensure that it has been implemented, we have two processes from the monitoring and controlling process group.

Using documents such as the project charter and quality management plan, we develop a scope management plan and a requirement management plan, which tell us how to develop, control, and validate the scope of the project and product, called scope or sometime project scope. Based on the scope management plan and the requirement management plan, we use the Collect Requirement process to collect project and product requirements and put them into requirement documentation, and also to create a requirement traceability matrix to monitor the requirements by linking them to project objectives, deliverables, status, and so forth. This requirement documentation is used for the rest of the scope processes, a reflection of the fact that requirements directly or indirectly affect multiple project aspects, including scope, schedule, cost, risk, and procurement. With requirement documentation in our hands, we use the Define Scope process to develop the project scope statement, a document that consists of both project scope and product scope.

The project scope statement, along with requirement documentation, is used to create the WBS, a hierarchical structure in which the project scope is broken down into manageable tasks, which can be assigned to team members. The process Create WBS also creates the WBS dictionary, which offers details for the WBS component such as schedule milestones, cost estimate, and quality requirements.

The WBS, WBS dictionary, and project scope statement constitute the scope baseline, an output of the Create WBS process, against which the actual work results are compared. The scope is controlled by the Control Scope process, and the scope of verified deliverables is validated using the Validate Scope process.

Road Ahead. Now that you have project scope—i.e., project and product scopes—figured out, you are one step closer to starting project execution. Before we start project execution, we will need to develop a schedule for it. We will show how to do so in the next chapter.

Exam's Eye View

Comprehend

- The scope management plan developed from the project charter is a blueprint that will show how to develop, control, and validate the scope.
- The stakeholder register generated by the Identify Stakeholders process is an input item to collecting requirements, and so is the project charter.
- The requirement documentation generated by the Collect Requirements process is an input to defining the project scope.
- The project charter and the requirement documentation are input items to the Define Scope process that is used to develop the project scope statement.
- The project scope statement and requirement documentation are input items to creating the WBS.
- The scope baseline consists of project scope statement, WBS, and WBS dictionary and is generated by the Create WBS process.
- Requirements, themselves and through the project scope statement, WBS, and WBS dictionary, i.e., scope baseline, affect just about all important aspects of a project, such as schedule, resources, cost, quality, procurement, and risk.

Look Out

- Do not confuse project scope with product scope. The product scope consists of the features and functions that characterize a product to be delivered by the project, whereas the project scope is composed of the work that must be performed (and only that work) to deliver products with specified features.
- The project scope statement contains both the project scope and project product scope.
- All change requests generated by controlling scope or any process must be processed through the Integrated change Control process for approval, and only approved changes should be implemented by using the Direct and Manage Project Work process.
- The Validate Scope process is used on the project deliverables already verified by the Quality Control process; the goal is to get deliverables accepted by the appropriate party, such as customer or sponsor.
- The scope statement, the WBS document, and the WBS dictionary combined constitute the scope baseline against which the actual work results are compared.

Memorize

- Most of the information in the WBS dictionary is generated by other processes and not by the Create WBS process.
- Control accounts are the points in the WBS at which scope, schedule, and cost are integrated for the purpose of monitoring and controlling the performance.
- The Plan Scope Management process generates two plans: scope management plan and requirement management plan.

Review Questions

1. Which of the following is a false statement about the WBS?
   A. A control account may have many code of account identifiers.
   B. You should keep decomposing WBS components to lower levels until necessary and sufficient decomposition has been achieved.
   C. Each work component appears in the WBS once and only once.
   D. The work packages should appear from left to right in the order in which the work will be performed.
2. Which of the following is done first?
   A. Creating the scope statement
   B. Creating the WBS
   C. Creating the requirement documentation
   D. Creating the project charter
3. The WBS is the output of which of the following processes?
   A. The Create WBS process
   B. The Define Scope process
   C. The Develop WBS process
   D. The Project Initiating process
4. The project scope statement is the output of which of the following processes?
   A. The Create WBS process
   B. The Define Scope process
   C. The Create Project Scope process
   D. The Project Initiating process

5. Which of the following is a false statement about the output of the plan scope management process that creates the project scope management plan?

    A. It describes how to verify the project scope.

    B. It describes how to control the project scope.

    C. It doesn't describe how to manage the requirements.

    D. It describes how to define the product scope.

6. What are the components in the lowest level of the WBS hierarchy collectively called?

    A. Work packages

    B. Control accounts

    C. Phase

    D. Milestones

7. Choose what is included in the project scope statement:

    A. Project scope

    B. Product scope

    C. Assumptions and constraints

    D. Some things that the project is not going to do

8. Which one of the following constitutes the project scope baseline?

    A. The WBS document and the scope statement

    B. The scope statement

    C. The WBS document

    D. The WBS, the WBS dictionary, and the scope statement

9. Who creates the WBS?

    A. The project manager alone

    B. The upper management in the performing organization

    C. The customer

    D. The project manager with help from the project team

10. Which of the following is not included in the project scope statement?

    A. Project assumptions and constraints

    B. The WBS

    C. Product description

    D. Project deliverables

11. You are in the process of developing the requirement management plan for your project. You will develop this plan:

    A. By performing the Develop Requirement Plan process

    B. By performing the Plan Scope Management process

    C. There is no process for it.

    D. During the initiation stage of the project

12. You are in the planning stage of a project. Walking down the hallway, your supervisor mumbles, "Don't forget job shadowing." Job shadowing is a technique used in:

    A. Defining the project scope

    B. Collecting product requirements

    C. Creating the WBS

    D. Developing the stakeholder management strategy

13. You are planning the scope for your project. You have just created the requirement documentation after meeting with the stakeholders and studying the project charter and so forth. This requirement documentation can be used in developing:

    A. Project scope statement

    B. The WBS

    C. The work performing information

    D. The project scope statement and the WBS

14. Which of the following is the correct order of running processes? Choose all that apply.

    A. Develop Project Charter, Collect Requirements, and Create WBS

    B. Collect Requirements, Control Quality, and Validate Scope

    C. Identify Stakeholders, Define Scope, and Collect Requirements

    D. Collect Requirements, Validate Scope, Control Quality

15. You have selected a node in the hierarchy of the WBS that you will use to compare schedule, cost, and scope with the earned value in order to measure the project performance. This node or component in the WBS is called:

    A. Code of accounts

    B. Control account

    C. Management account

    D. Performance node

16. You are the project manager for a software product, and your project is in the execution stage. You have learned that Maya, a developer, has started adding some new features to the deliverable she is working on. What is the best action for you to take?

    A. Tell Maya to delete the code corresponding to these features because this is a scope creep, and scope creeps are not allowed.

    B. Learn from Maya what those features are and how much time they will take and then make necessary updates to the WBS, the WBS dictionary, and the schedule. Also tell Maya that in the future she should get approval from you before adding any new features.

    C. Determine where the request for the new features came from and process the change request through the integrated change request process.

    D. Contact Maya's functional manager and ask the manager to replace Maya with another developer.

CHAPTER

5

Project Schedule Management

The objectives covered in this chapter make up 9 percent of the CAPM exam, equivalent to about 12 questions. Study the whole chapter in detail.

It's enough to just remember the name of the input, tools and techniques, and outputs. You should know what is in a given input item that the given process uses and how that helps in generating the output, as well as what a given tool or technique does in a given process.

You should be very clear about the purpose and procedures related to sequencing activities and should be able to interpret various types of network diagrams to identify critical path activities and so forth.

While studying this knowledge area and its processes, pay attention to how the tasks can be tailored or adapted to your needs, and recognize an agile environment in action; for example, continual assessment generates change requests which lead to changing plans—i.e., adapting.

P. Sanghera, *CAPM® in Depth*, https://doi.org/10.1007/978-1-4842-3664-2_5

CAPM Exam Objectives

Project Schedule Management:

1. Define the six project management processes in the project schedule management knowledge area.
2. Identify the input, tools and techniques, and outputs defined in the six processes in project schedule management.
3. Solve simple network diagram problems and perform basic scheduling calculations.
4. Identify considerations for agile/adaptive environments in project schedule management.

At its core, a project consists of two main components: the project work that needs to be performed and the schedule to perform that work. As you learned in the previous chapter, the overall project work—i.e., the project scope—is broken down into smaller, more manageable components. These components in the WBS are called *work packages*. However, a work package might not be a suitable item to assign to an individual to perform. So, work packages can be rearranged or decomposed into smaller components called *activities*. A project schedule contains not only the activities to be performed, but also the order, or sequence, in which the activities will be performed and the start and finish dates. The sequencing of activities is constrained by the dependencies among the activities. A realistic project schedule can be created from the bottom up by identifying the activities, estimating the resources needed for the activities, and determining the time that each activity will take with the given resources available. The schedule, once developed and approved, needs to be controlled to stay on track. All these tasks belong to what is called project schedule management.

So, the main issue in this chapter is schedule management. To enable you to wrap your mind around this issue, we will explore the following three avenues: generating or collecting the data about the project schedule, such as determining activities and their characteristics, including dependencies among activity, resource requirements, and activity durations; building a project schedule from the data on the activities; and controlling the schedule.

Project Schedule Management: Big Picture

Developing and controlling the project schedule so as to complete the project work in time is what schedule management all about. To complete a project, you need to perform some activities to produce the project deliverables. To make that happen, you need to estimate resources for the activities and schedule the activities. But before all this can happen, you need to identify the activities. One thing more: all this should happen as planned.

Note The process of estimating activity resources belongs to the resource management area and will be discussed in the next chapter.

Although all this sounds like common sense, it makes sense to define the following terms so we are all on the same page:

- **Activity.** A component of project work.
- **Activity Duration.** The time measured in calendar units between the start and finish of a schedule activity.
- **Schedule Activity.** A scheduled task (component of work) performed during the lifecycle of a project.
- **Logical Relationship.** A dependency between two project schedule activities or between a schedule activity and a schedule milestone.
- **Schedule Milestone.** A milestone is a significant point (or event) in the life of a project, and a schedule milestone is a milestone on the project schedule. A milestone refers to the completion of an activity, marking possibly the completion of a set of activities, and therefore has zero duration. The completion of a major deliverable is an example of a milestone.

Project time management includes the processes required to complete the project in a timely manner. Figure 5-1 presents the flow diagram for the time management processes that lead to schedule development.

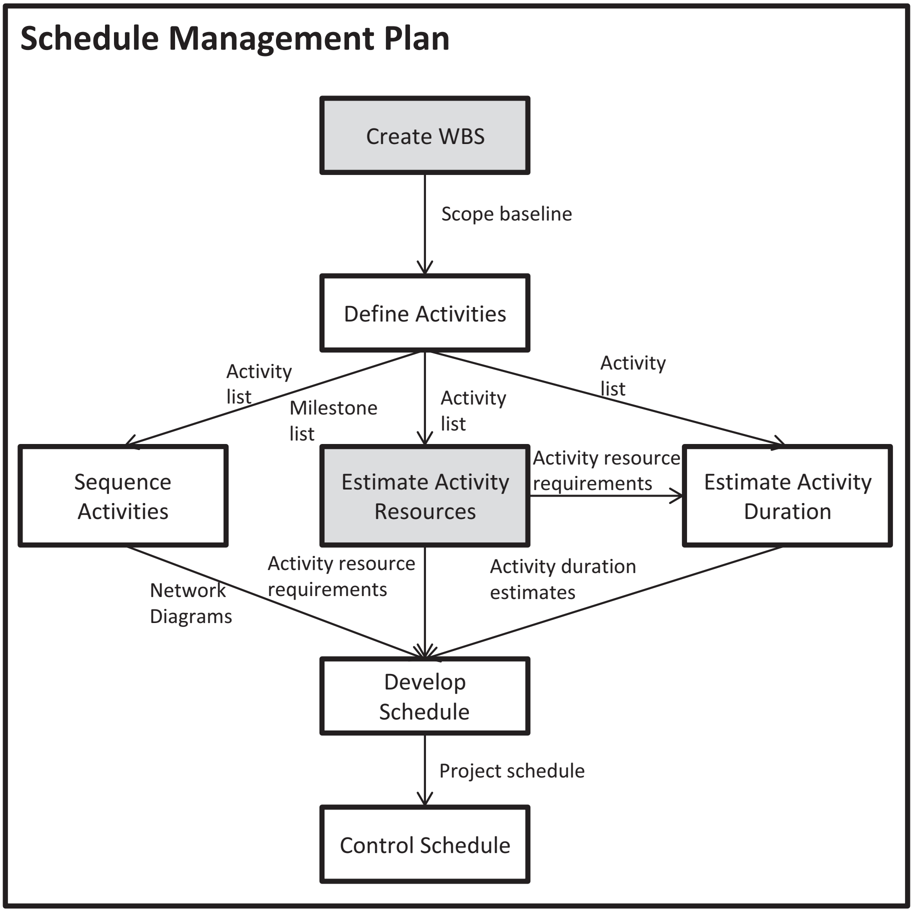

Figure 5-1. The schedule management processes that lead to schedule development. The processes shown in gray are not from the schedule management knowledge area.

The usages of these processes are listed here:

- **Plan Schedule Management.** Plans how to develop, execute, and control the project schedule.
- **Define Activities.** Identifies the specific schedule activities, or pieces of work, that must be performed to produce the project deliverables.
- **Sequence Activities.** Puts the activities to be scheduled in a sequence by identifying the dependencies among them.

- **Estimate Activity Duration.** Estimates the time in units of work periods required for each schedule activity's completion. A work period is a measurement of time when the work is in progress; it is measured in hours, days, or months, depending upon the size of the activity. This estimate is performed for given resources.
- **Develop Schedule.** Develops the project schedule by analyzing schedule activity sequences, schedule activity durations, resource requirements, and schedule constraints.
- **Control Schedule.** Monitors the status of the project's progress to manage the resulting changes in project schedule and hence in the schedule baseline.

These processes are listed in Table 5-1 along with their process groups and the major output from each process.

Table 5-1. Processes of Scope Management Mapped to the Process Groups

Time Management Process	Process Group	Major Output	Performed
Plan Schedule Management	Planning	Schedule management plan	Once at predetermined project points
Define Activities	Planning	Activity list, milestone list	Throughout the process
Sequence Activities	Planning	Project schedule network	Throughout the process
Estimate Activity Durations	Planning	Activity duration estimates	Throughout the process
Develop Schedule	Planning	Project schedule	Throughout the process
Control Schedule	Monitoring and Controlling	Work performance measurements	Throughout the process

Note The underlying philosophy of project management for schedule development is to first develop the schedule based on the work required to complete the project tasks, and then see how you can make it conform to other constraints, calendar requirements, and strategic goals of the organization. You build the schedule through cold, hard mathematical analysis, and you don't just accept whatever schedule goals come down the pipeline from elsewhere, such as from the customer or the project sponsor.

In a nutshell, the path to schedule development includes defining activities, arranging the activities in the correct logical order, and getting the resources estimate for the activities. In other words, the work necessary for completing the project is expressed in terms of activities and the resources required to complete those activities. But, like anything you do in project management, you have to plan schedule management.

Planning Schedule Management

As mentioned earlier, the Plan Schedule Management process is about planning how to develop, execute, and control the project schedule. This process is performed using the input and tools and techniques shown in Table 5-2 to generate a schedule management plan.

Table 5-2. The Plan Schedule Management process: Input, tools and techniques, and output

Input	Tools and Techniques	Output
1. Project charter 2. Project Management Plan: • Scope management plan • Product development approach management plan 3. Enterprise environmental factors 4. Organizational project assets	1. Data analysis 2. Meetings 3. Expert judgment	Schedule management plan

I will explain how to perform this process in terms of the following steps that you take to develop the schedule management plan from input and tools and techniques.

1. Start with the *scope management plan*, which provides some information on how to develop the schedule.
2. Study the document on *product development approach*. As the schedule you want to develop is for producing the product, this approach will help in almost all aspects of schedule management, including estimating techniques, scheduling tools, and schedule-controlling techniques. It will help in determining the general scheduling approach.
3. Don't forget the milestone information from the project charter; you have to include that in the plan.

4. Make a list of the different methods or approaches that you come up with from steps 1 and 2 accounting in step 3. By *scheduling*, we mean schedule management, all the way from defining activities to developing and controlling the schedule.

5. For planning a given process, use data-analysis techniques, such as alternative analysis, to pick one or a combination of methods from the list from step 4. Also, we can use such data-analysis methods to strike the appropriate balance between schedule details and time taken to update the schedule.

While executing the preceding five steps, you can also hold meetings with appropriate stakeholders such as the project sponsor and those who have responsibilities regarding the schedule or will be affected by it. Of course, you can seek expert judgment on related topics, such as schedule development and control, scheduling software tools, and scheduling methods.

Knowing this much about this process, you should be able to figure out the EEFs and OPAs for it; see Study Checkpoint 5.1.

STUDY CHECKPOINT 5.1

Q1. Using your knowledge of enterprise environmental factors and the plan schedule management process, make a list of EEFs that would influence this process.

Q2. Using your knowledge of organizational project assets and the plan schedule management process, make a list of OPAs that would influence this process.

The output of these efforts just described generates the schedule management plan.

Schedule Management Plan

The schedule management plan document records how to develop, execute, and control the project schedule. Table 5-3 describes it in terms of some questions and answers.

Table 5-3. Schedule Management Plan

Questions	Schedule Management Plan
What is the chosen schedule development model?	Describes the chosen methods and tools for the development of the schedule
What are the organizational procedure links?	Refers to the WBS being used in this project as a framework for schedule development. Purpose: provides consistency in work scope and scheduling that work.
How do you maintain the chosen schedule model?	Describes the processes used to record the schedule progress status and update the schedule model
What are the lengths of time-boxed periods?	Specify the lengths of time-boxed periods for release, iterations, and waves. A time-boxed period is the duration for which a team works to finish a certain amount of work in a steady fashion.
What are the units of measurement?	Defines units of quantities: hours, days, or months for time; meters/yards for length, and kilograms/pounds for weight.
What is the level of accuracy?	Specify the accuracy or uncertainty in estimating the countable and measurable variables; i.e., It will take 25±5 days to complete this activity; here, *5 days* is level of accuracy.
What are the rules of performance measurements?	Describes the rules for measuring the performance of various quantities; e.g.; performance in schedule is measured in terms of magnitude of variations from the original schedule baseline.
What are the control thresholds?	Specify the allowed maximum performance variance above which an action request will be triggered.
What are the frequency and reporting formats?	States the frequency and reporting formats for various reports.

Note The time-boxed periods are used in projects with adaptive lifecycles. They help you avoid scope creep by making the team focus on essential works within the scope.

With the schedule management plan in your hands, the first step toward schedule development is defining activities.

Defining Activities

Activities are pieces of work that need to be performed to produce the project deliverables. However, first we need to identify them, and we do that using the Define Activities process, which has the input, tools and techniques, and output shown in Table 5-4.

Table 5-4. The Define Activities Process: Input, Tools and Techniques, and Output

Input	Tools and Techniques	Output
1. Project Management Plan: • Schedule management plan • Scope baseline: scope statement, WBS, WBS dictionary 2. Enterprise environmental factors 3. Organizational project assets	1. Decomposition 2. Rolling wave planning 3. Expert judgment	1. Activity list 2. Activity attributes 3. Milestone list 4. Change requests 5. Updates: • Scope baseline • Cost baseline

The main steps to perform this process, using the information from Table 5-4, are described in the following sections.

Raw Data for Defining Activities

This process identifies activities, or pieces of work, that will need to be completed in order to deliver the project outcome. In the previous chapter, we covered WBS all the way up to work packages; that is where identifying project activities starts. So, the starting point for defining activities is the lowest level of the WBS that contains work packages. Basically, each work package is broken down into one or more activities.

Recalling that WBS is derived from the project scope statement. The items described in the following hold that data or information that we need in order to identify activities.

Project Scope Baseline. The following three components of the project scope baseline are needed to define activities:

- **WBS and WBS dictionary.** The work packages in the WBS are decomposed into project activities. To define activities in detail so that you can assign appropriate resources to them, you need details about the work packages, which are provided in the WBS dictionary.

- **Project Scope Statement.** The WBS is built from the project scope statement. While dealing with the WBS, you might need to go back to the project scope statement. The following elements of the project scope statement are especially important to consider while identifying activities:
    - Assumptions related to the activities or schedule planning, such as work hours per week
    - Constraints that will limit the schedule options, such as predetermined deadlines on project milestones
    - Project deliverables, to ensure everything is covered in the WBS work packages

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Tip The WBS dictionary also contains the milestone dates, which traveled all the way from the project charter.

In order to perform this process effectively, we must be aware of the following EEFs and OPAs that can influence the process:

- **Enterprise Environmental Factors.** The enterprise environmental factors relevant to identifying schedule activities include project management information systems and project scheduling software tools, published information from commercial databases, and organizational structure and culture.
- **Organizational Process Assets.** The following are examples of organizational process assets that can influence the process or be useful in the process of identifying activities:
    - Organizational policies related to activity planning
    - Organizational procedures and guidelines used in defining activities
    - Templates and other information from previous projects that is used in defining activities
    - Knowledge base of lessons learned from previous rojects regarding activity lists

So, we use the raw data of the information discussed in this section to generate the output of the Defining Activities process.

Generating the Output of Defining Activities

The key output item of the activity definition process is a comprehensive list of all the activities that need to be performed to produce the project deliverables. This is obtained by breaking down the work packages using the decomposition and rolling wave techniques discussed in the previous chapter. Activities make up the core of a project. So, it's very important to identify and define them correctly so as to make the project schedule efficient and effective. Expert judgment is a very important tool that can be used in this process. For example, during the process of decomposing the work packages into schedule activities, you can use the help of team members and other experts who are experienced in developing WBS and project schedules. In addition to this, you can hold meetings with relevant stakeholders.

This and other output items are discussed in the following list.

Activity List. This is a list of all the activities that are necessary and sufficient to produce the project deliverables; each activity is assigned its own unique identifier within the WBS. In other words, these activities are derived from the WBS and hence are within the scope of the project. Also, the scope of each schedule activity should be described in sufficient detail and in concrete terms so that the team member responsible for it will understand what work needs to be performed. Examples of schedule activities include a chapter of a book, a function of a computer program that will accomplish a well-defined task, and an application to be installed on a computer.

Activity Attributes. In addition to the scope description, each activity also has some attributes assigned to it, as follows:

- Unique activity identifier (ID) and WBS ID
- Activity description
- Assumptions and constraints related to this activity, such as imposed deadline
- Predecessor and successor activities
- Resource requirements
- Team member responsible for performing the work and information about the work; for example, where it will be performed.

Some attributes are assigned not at once, but over time. The attributes are used to arrange the activities in the correct order (sequencing) and to schedule them.

Caution! The Define Activities process generates the final output as activities and not deliverables. Therefore, ideally speaking, the WBS and the WBS dictionary should be generated before defining activities. However, practically speaking, the activity list, the WBS, and the WBS dictionary can be developed concurrently.

Milestone List. This list comes from the WBS dictionary. Recall, a schedule milestone is a point in time by which a certain amount of project work will be finished. It may include the completion of a major deliverable. They can be mandatory or optional, and can be built into the schedule.

Change Requests and Updates. Deliverables are broken down into work packages, which are subsequently broken down into activities in a rolling wave or progressive elaboration fashion. This may create the need to modify the baseline, which may affect the cost baseline. But, to make a change to any baseline, you must create a change request, which would be processed through the Perform Integrated Change Control process. If the change is approved and implemented, the scope baseline and cost baseline documents may need to be updated accordingly.

Tip You create the WBS and decompose the work packages to project activities with the help of the project team. Even though the schedule is not yet developed and the resources are not fully assigned, the project team in some initial form will be there. When decomposing a work package into activities, involve the individuals who either are familiar with the work packages or will be responsible for them.

Note Rolling wave planning is an example of progressive elaboration, which was discussed in Chapter 4.

Before you can schedule them, the identified activities need to be arranged in the correct order, which is called *sequencing*.

Sequencing Activities

The activity sequencing process is used to arrange the schedule activities in the appropriate order, which takes into account the dependencies among the activities. For example, if activity B depends upon the product of activity A, then activity A must be performed before activity B. So, the activity sequencing has a two-pronged goal—to identify the dependencies among the activities and to order the activities accordingly. Table 5-5 shows the activity sequencing process in terms of its input, tools and techniques, and output.

Note One main advantage of sequencing activities is that it is a way to handle project constraints in the most efficient manner.

Table 5-5. The Sequence Activities Process: Input, Tools and Techniques, and Output

Input	Tools and Techniques	Output
1. Project Management Plan: • Schedule management plan • Scope baseline: scope statement, WBS, WBS dictionary 2. Project documents: • Activity list • Activity attributes • Milestone list • Assumptions log 3. Enterprise environmental factors 4. Organizational project assets	1. Determining dependencies 2. Precedence diagramming method (PDM) 3. Applying leads and lags 4. Project management information system	1. Project schedule network diagrams 2. Updates: • Activity list • Activity attributes • Milestone list • Assumptions log

The main goal of this process is to generate schedule network diagrams.

From Activities to Project Schedule Network Diagrams

The main steps of this process, using the information from Table 5-5, are described in the following:

1. Study any related program and portfolio plans; they may reveal some dependencies among activities.
2. From the *schedule management plan*, find out the information on sequencing activities, such as methods to be used, level of accuracy, and other criteria.
3. Examine the *scope baseline*, from which the activities were derived, including WBS and WBS dictionary, deliverables, and assumptions and constraints, to collect any information that could help to extract the relationship between the activities.

4. Use the *assumptions log* to study how the assumptions might influence the relationship between activities. For example, if an assumption is that an event would happen by a certain date, on which the start of activity B depends, and it does not happen, then activity B has to be delayed, which in turn may give rise to early and late starts for some activities, called leads and lags, covered in the next section.
5. From the *milestone list*, collect the milestones that already have scheduled dates because that will influence their relationship with other activities.
6. Using the information from step 1 through step 5 and information from the *activity attributes* document,
    a. determine the dependency relationship between the activities listed in the activity list, and
    b. generate the project schedule network diagrams using the tools and techniques discussed in the next section.

Tools and Techniques for Generating Project Schedule Network Diagrams

Dependency determination is the prerequisite to determining sequencing. Therefore, most of the tools and techniques used for sequencing are focused on determining and displaying the dependencies.

Determining and Integrating Dependencies

These types of dependencies describe the logical relationships between activities. Where do these relationships come from? To answer this question, the dependencies can be grouped into three categories, as follows:

- **Mandatory Dependencies.** These are the dependencies inherent to the activities or required by law and a contract. For example, that a software program must be developed before it can be tested is inherent to these activities. Mandatory dependencies are also referred to as *hard logic* or *hard dependencies*.

- **Discretionary Dependencies.** These are the dependencies followed at the discretion of the project team. For example, it was possible to perform activities A and B simultaneously or to perform A after B was finished, but the team decided, for whatever reason, to perform B after A was finished. Some of the guidelines for establishing discretionary dependencies can come from the knowledge of best practices within the given application area and from the previous experience of performing a similar project. Discretionary dependencies are also referred to as soft logic, preferential logic, or preferred logic.
- **External Dependencies.** An external dependency involves a relationship between a project activity and a non-project activity—that is, an activity outside the project. For example, in a movie production project, think of a project activity that involves shooting scenes with lots of tourists skiing. This scene is planned to be shot at a skiing resort during the skiing season. This is an example of an external dependency.
- **Internal Dependencies.** An internal dependency involves a relationship between two project activities that are under the control of the project. For example, it convenient for the team to perform B after A.

Careful readers may have realized that all of these categories are not exclusive; there may internal and external mandatory dependencies, and internal and external discretionary dependencies. This is integration.

The dependency between two schedule activities is an example of the logical relationships defined earlier in this chapter. Logical relationships can be displayed in schematic diagrams, called *project schedule network diagrams*, or just *network diagrams* for brevity. A common method used to develop network diagrams is called the precedence diagramming method (PDM).

Precedence Diagramming Method (PDM)

To properly sequence the schedule activities, you need to determine the dependencies among them. As illustrated in Figure 5-2, a dependency relationship between two activities is defined by two terms: predecessor and successor. In other words, when two activities are in a dependency relationship with each other, one of them is a predecessor of the other, and the other one is the successor. In Figure 5-2, activity A is a predecessor of activity B, and activity B is successor of activity A. That means A must start before B.

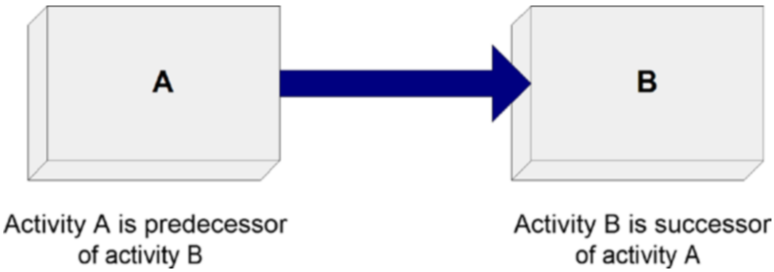


Figure 5-2. Predecessor/successor relationship between two activities

By definition, the successor activity must start after the predecessor activity has already started. But exactly when can the successor activity start after the predecessor activity has already been started? Well, both the predecessor and the successor have a start and a finish, and there are at maximum four possible combinations between the start and finish points of the predecessor and successor activities. Accordingly, there are four kinds of dependencies, also called *precedence relationships* or *logical relationships*, listed here:

- **Finish to Start.** The initiation of the successor activity depends upon the completion of the predecessor activity—that is, the successor activity cannot be started until the predecessor activity has already been completed.
- **Finish to Finish.** The completion of the successor activity depends upon the completion of the predecessor activity—that is, the successor activity cannot be completed until the predecessor activity has already been completed.
- **Start to Start.** The initiation of the successor activity depends upon the initiation of the predecessor activity—that is, the successor activity cannot be initiated until the predecessor activity has already been initiated.
- **Start to Finish.** The completion of the successor activity depends upon the initiation of the predecessor activity—that is, the successor activity cannot be completed until the predecessor activity has already been initiated.

The precedence diagramming method (PDM) is the method used to construct a project schedule network diagram. It does so by connecting the activities in a schedule to each other by their logical relationships. In a diagram, a box (for example, a rectangle) is used to represent an activity and an arrow is used to represent a dependency between two activities. The boxes representing activities are called *nodes*. Figure 5-3 presents an example of a network diagram constructed using PDM, in which activity A is a predecessor of activity B; activity C is a predecessor of activities D and G; and D is a successor of C; and so on.

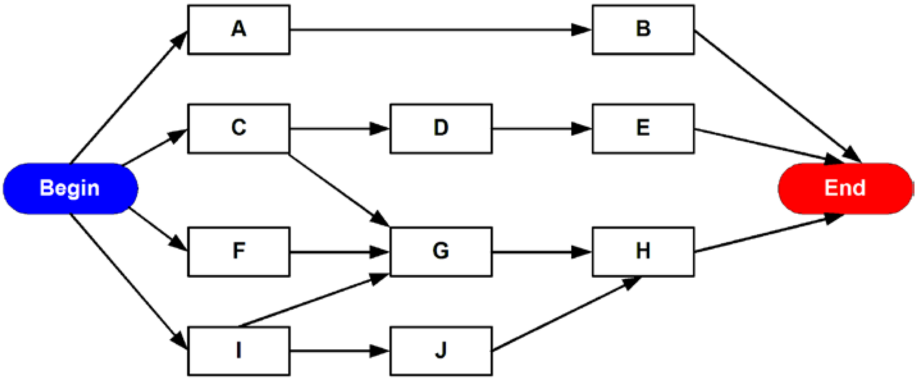


Figure 5-3. An example of a project schedule network diagram constructed by using the precedence diagramming method (PDM)

In this diagram, only C and I have more than one successor. In general, PDM supports all four kinds of precedence relationships discussed earlier, but the most commonly used dependency relationship in PDM is finish-to-start. The start-to-finish relationship is rarely used.

Applying Leads and Lags. In the real world, some activities may need or lend to what are called leads and lags in order to accurately or effectively define the logical relationships. For example, the finish-to-start dependency means that the successor activity starts when the predecessor activity finishes. Applying a lead means you allow the successor activity to start before the predecessor activity finishes, and applying a lag means you start the successor activity a few days after the predecessor activity finishes. Sometimes, you might need to make such adjustments in the schedule for effectiveness and efficiency. Of course, leads and lags are measured in units of time, such as days.

Caution! The project management information system (PMIS) can be used as a tool to produce and display the project schedule network diagrams. It can also be counted as part of the input to the Sequence Activities process because it is an enterprise environment factor.

STUDY CHECKPOINT 5.2

Q1. What is the most common logical relationship used in schedule network diagrams?

Q2. What is the least common logical relationship used in schedule network diagrams?

Q3. Make a list of EEFs and OPAs that could influence the process of scheduling activities.

We have already described the main output of this process: project schedule network diagrams. As a result of the discovery of relationships among activities, the documents listed in the output column of Table 5-5 may need to be updated. During the process of sequencing activities, you may identify new necessary activities, split an activity into two, modify activity attributes, add new attributes, or identify a risk related to an activity. Accordingly, you may need to modify the project documents, such as activity list, activity attributes, and risk register.

Once the activities have been identified and the resources required to perform them have been gathered, as shown in the next chapter, you have enough information to begin estimating the time needed to complete each activity, which is called the *activity duration*.

Estimating Activity Duration

Activity duration is the time between the start and finish of an activity. Activity duration is estimated in work periods by using the Estimate Activity Durations process for the given resources assigned to the activity. A work period is a measurement of time when the work is in progress; it is measured in hours, days, or months, depending upon the size of the activity. This estimate can be converted to calendar units of time by factoring in the resource's passive time, such as holidays. For an example, suppose you have estimated that it will take one programmer four days (with eight work hours in a day) to write a program. You also know that the work will start on a Friday and there will be no work on Saturday and Sunday. Therefore, the activity duration estimate is four days (or 32 hours) measured in work periods and 6 days measured in calendar units.

Table 5-6 shows the input, tools and techniques, and output for the activity duration estimating.

Table 5-6. The Estimate Activity Durations Process: Input, Tools and Techniques, and Output

Input	Tools and Techniques	Output
1. Project Management Plan: • Schedule management plan • Scope baseline: scope statement, WBS, WBS dictionary 2. Project documents: • Activity list • Activity attributes • Milestone list • Assumptions log • Risk register • Team assignments • Resource calendars • Resource requirements • Resource breakdown structure 3. Enterprise environmental factors 4. Organizational project assets	1. Analogous estimating 2. Parametric estimating 3. Three-point estimating 4. Alternative analysis 5. Reserve analysis 6. Decision making 7. Expert judgment 8. Meetings	1. Activity duration estimates 2. Basis of estimates 3. Updates: • Activity attributes • Assumptions log • Lessons learned register

Performing the Estimate Activity Durations process means: 1) extract the information, activities, resources, and any other estimate-related information from the input types shown in Table 5-6, and 2) estimate duration for each activity by applying the tools given in Table 5-6. You do this according to the schedule management plan, which also tells you about what accuracy level to use for these estimates and any other criterion. You can also examine the assumptions log and risk register for assumptions and risks that may potentially impact the activity durations. For example, you may be assuming that a technology will be installed before the project starts, which would make certain activities complete faster. What if the installation doesn't happen?

Collecting the activity and resource information is discussed in the following sections.

Activity and Resources Information for Duration Estimation

As mentioned earlier, to estimate the activity duration, you will need information about the activity, resource requirements for the activities, and the resources available for the activities. Let's look at some sources of this information, as listed in Table 5-6.

Activity List and Activity Attributes. These documents will provide a list of activities whose durations need to be estimated, as well as activity attributes, which will help in estimating the durations. For example, if activity attributes tell us activity A would be performed before activity B, and if part of what is done during A can be used in B, then it will shorten the duration of B.

Project Scope Baseline. The technical details of the WBS dictionary in the scope baseline may affect the duration of some activities. Some assumptions and constraints in the project scope statement, another component of the scope baseline, can affect activity duration estimates as well. For example, there might be an assumption that part of the work related to an activity has already been performed in a previous project and can be used in this project. If the assumption is true, the activity duration will be less than otherwise. An example of a constraint might be that a specific work package must be finished before a predetermined deadline. This will put a maximum limit on the duration for activities corresponding to this work package.

Activity Resource Requirements. The activity durations, by definition, are estimated for given resources. In other words, the work periods required to complete an activity depend on the resources assigned to the activity. For example, suppose it will take four work days to complete an activity that involves having two programmers write two programs. If only one programmer is available, it will take roughly eight work days to finish this activity, given both programmers are skilled. However, while assigning additional resources to an activity, always consider the following:

- Sometimes assigning additional resources might reduce the overall efficiency and productivity. For example, think of two engineers with different skill levels assigned to work on interrelated components of an activity.
- Most of the activities have a threshold beyond which assigning additional resources does not help. For example, installing an operating system on machines; each given machine will take the same amount of time regardless of how many system administrators have been assigned to this activity.

Resource Breakdown Structure, Resource Calendar, and Team Assignments. Resource Breakdown Structure (RBS) is a hierarchical structure that displays the identified resources by category and type. The resource calendar, finalized (or modified) during the activity resource estimating, contains the type, quantity, availability, and capability of each resource, including the skills of a human resource, which must be considered during activity duration estimating. For example, an experienced programmer can finish the same program in less time than a beginner can. This is where team assignments come into play.

Also, capability and quantity of available resources, both human and material, can affect the activity duration estimate. For example, if an activity will take four work days for an engineer to finish, and the engineer can work only four hours a day on this activity, it will take eight calendar days to finish.

STUDY CHECKPOINT 5.3

Q1. Describe which EEF can influence the process of estimating activity durations.

Q2. Describe which OPA can influence the process of estimating activity durations.

The activity duration estimate is a non-trivial task, and there are various tools and techniques available to perform this task effectively and reliably. We next apply these tools to the information collected in this section to estimate the duration.

Tools and Techniques for Activity Duration Estimating

The project schedule depends upon the activity duration estimates. The duration estimates of activities on the critical path will determine the finish date of a project for a given start date. However, there might be many uncertainties involved in the estimate. For example, two programmers, due to the differences in their experience, will take different amounts of time to write the same program.

The good news is that there are a number of tools and techniques that you can use in activity duration estimating.

Analogous Estimating. Analogous estimating techniques estimate the duration of an activity based on the duration of a similar activity in a previous project. The accuracy of the estimate depends upon how similar the activities are and whether the team member who will perform the activity has the same level of expertise and experience as the team member from the previous project. This technique is useful when there is not enough detail information about the project or a project activity available—for example, in the early stages of a project. This technique can be applied to the whole project or a part of it.

Parametric Estimating. This is a quantitative technique used to calculate the activity duration when the productivity rate of the resource performing the activity is available. You use a formula such as the following one to calculate the duration:

Activity duration = Units of work in the activity/
Productivity rate of the resources

For example, if your team is assigned to the activity of repairing 40 miles of road, and you know from data that the average rate for repairing such a road by a similar team was half a mile per day, then the duration calculation can be performed as follows:

$$Activity\,duration = 40\ miles / \left(0.5\ miles / day\right) = 80\ days$$

Three-point Estimating. This method addresses the issue of uncertainty in estimating the activity duration. The uncertainty in the duration estimate can be calculated by making a three-point estimate in which each point corresponds to one of the following estimate types:

- **Most-likely Scenario.** The activity duration is calculated in the most practical terms by factoring in the resources likely to be assigned and realistic expectations of the resources, dependencies, and interruptions.
- **Optimistic Scenario.** This is the best-case version of the situation described in the most-likely scenario.
- **Pessimistic Scenario.** This is the worst-case version of the situation described in the most likely scenario.

The spread of these three estimates determines the uncertainty. The resultant duration is calculated by taking the average of the three estimates. For example, if the duration for an activity is estimated to be 30 days for the most-likely scenario, 27 days for the optimistic scenario, and 33 days for the pessimistic scenario, then the average duration is 30 days and the uncertainty is ± 3 days, which can be expressed as follows:

$$duration = 30 \pm 3\ days$$

It's equivalent to saying that the activity duration is 30 days, give or take three days.

In general, the duration value is obtained by adding the three values and dividing by three. However, the most-likely scenario may be given more weight than the other two scenarios. Therefore, the expected duration can be calculated by using the following formula:

$$t_e = \left(nt_m + t_o + t_p\right) / \left(n + 2\right)$$

where *te* is the expected duration, *tm* is the duration in the most-likely scenario, *to* is the duration in the optimistic scenario, *tp* is the duration in the pessimistic scenario, and *n* is the weight given to the most-likely scenario.

STUDY CHECKPOINT 5.4

In the program evaluation and review technique (PERT), the most-likely scenario is given a weight of 4 as compared to the weight of 1 for each of the pessimistic and optimistic scenarios. The pessimistic estimate for an activity is 20 days, the optimistic estimate is 10 days, and most-likely estimate is 15 days. Calculate the expected estimate using the PERT technique.

Bottom-up Technique. This technique is used when it's difficult to estimate the duration of an activity; for example, it's big in size or complicated. This technique decomposes the activity into smaller pieces, estimates the durations of those pieces, and aggregates all those duration values into one final value.

Alternative Analysis and Decision-Making Techniques. These techniques have been discussed several times in this book so far. Their basic ideas remain the same, but you can apply them to different situations. For estimating activity duration, you can use alternative analysis to estimate durations at different levels of resource capabilities, skills, and tools, then compare the results from different levels. Based on this comparison, hiring and buying decisions can be made using decision-making techniques.

Reserve Analysis. Reserve analysis is used to incorporate a time cushion into your schedule; this cushion is called a *contingency reserve*, a *management reserve*, or a *schedule reserve buffer*. The whole idea is to accommodate the possibility of schedule risks. One method of calculating the contingency reserve is to take a percentage of the original activity duration estimate as the contingency reserve. It can also be estimated by using quantitative analysis methods. Later, when more information about the project becomes available, the contingency reserve can be reduced or eliminated.

Expert Judgment and Meetings. Expert judgment can be used to estimate the whole duration of an activity when not enough information is available. It can also be used to estimate some parameters to be used in other methods—for example, what percentage of the original activity duration estimate should be used as a contingency reserve—and in comparing an activity to a similar activity in a previous project during analogous estimating.

Of course, meetings with relevant stakeholders will be useful.

Note that, in general, a combination of techniques is used to estimate the duration of an activity. For example, you can use the analogous technique and expert judgment to estimate the productivity rate of resources, and then use that productivity rate in parametric analysis to calculate the activity duration.

At the end of this road, you will have activity duration estimates with some document updates.

Output of Activity Duration Estimating

Guess what the main output of the activity duration estimating process is. Yes, you are right—it is the activity duration estimates! Regardless of which technique you use, these estimates are quantitative assessments of the required time units to finish activities, such as five days or ten weeks. As shown earlier, you can also assign an uncertainty to the estimate, such as 20±2 days, to say that the activity will take at least 18 days and at most 22 days. In addition to this, more information about the basis of these estimates should be documented; for example, how the estimates were made, what the assumptions and constraints were, and what the uncertainty is, including confidence level.

The duration of an activity is an attribute of the activity. Therefore, you must update the activity attributes, originally developed in the Define Activities process, to include the activity durations. Also, the assumptions made in estimating the durations will require the update of the assumptions log document. Last, you can update the lessons learned register with what techniques worked better than others.

By using the various processes discussed in this chapter, you have identified activities, arranged them in proper sequence, determined resource requirements for them as discussed in next chapter, and estimated their durations. All these tasks and accomplishments are a means to an end called *project schedule development*.

Developing the Project Schedule

The project work is composed of individual activities. The processes previously discussed in this chapter deal with the activities—defining activities, sequencing activities, and estimating activity durations—and so is the process of estimating resource requirements for the activities, covered in the next chapter. By using these processes, you work out a few schedule-related pieces at the activity level, which come together as the project schedule when you crank them up through the schedule development process, formally called Develop Schedule. Until you have a realistic project schedule, you do not have a project. A project schedule has activities sandwiched between the project start date and the project finish date. Table 5-7 shows the Develop Schedule process in terms of input, tools and techniques, and output.

Table 5-7. The Develop Schedule Process: Input, Tools and Techniques, and Output

Input	Tools and Techniques	Output
1. Project Management Plan: • Schedule management plan • Scope baseline 2. Project documents: • Activity list • Activity attributes • Resource requirements • Resource calendars • Project team assignments • Duration estimates and basis of estimates • Project schedule network diagrams • Milestone list • Assumptions log • Risk register • Lesson learned register 3. Agreements 4. Enterprise environmental factors 5. Organizational project assets	1. Schedule network analysis 2. Critical path method 3. Schedule compression 4. What-if scenario analysis 5. Resource optimization 6. Resource leveling 7. Simulations 8. Applying leads and lags 9. Project management information system 10. Agile release planning	1. Project schedule 2. Schedule baseline 3. Schedule data 4. Project calendar 5. Change requests 6. Plan updates: • Project schedule plan 7. Cost baseline 8. Project document updates: • Activity attributes • Duration estimate • Resource requirements • Assumptions log • Risk register • Lessons learned register

All the processes discussed in this chapter so far had a common goal: schedule development. This is directly and indirectly apparent from the input items in Table 5-7, which we use to extract the essentials for developing the project schedule.

Collecting Information for Schedule Development

The following output items from the schedule-related processes discussed in this chapter directly support the schedule development process:

- Activity list and activity attributes
- Project schedule network diagrams showing the dependencies among activities
- Activity resource requirements and resource calendars

- Activity duration estimates
- **Global Information.** The *WBS* and *WBS dictionary* will provide detail about the project deliverables, which are the real reason for the schedule. The *schedule development plan* will show "how" and what type of information—e.g.; what method and tools—should be used to create the schedule. Don't lose sight of this big picture while figuring out the schedule details.
- **Basic Activity-Related Information.** The *activity list* shows all the activities that need to be scheduled, and *activity attributes* help with the details of working out a schedule. The *duration estimates* document gives the activity duration estimates in work periods and the *basis of estimates* tells how these were obtained. The *resource requirement* document shows details about the resources assigned to each activity on which these estimates depend.
- **Activity Relationship–Related Information.** The information about dependencies among the activities and in which order they should be performed can be extracted from: 1) Schedule network diagrams; 2) milestones list with hardcoded, i.e., fixed, dates; and 3) resource calendars showing the availability of resources along the timeline.
- **Risk-Related Information.** This can be extracted from scheduled assumptions in the *assumptions log*, which may lead to risk, and schedule-related risks in the *risk register*. This information will help with risk mitigation by applying the *contingency reserve,* explained earlier in the chapter, in the project schedule.

Also, project-related *agreements* and *contracts* may have some information—e.g.; fixed deliverable dates—that you must consider while developing the schedule.

STUDY CHECKPOINT 5.5

Q1. Describe how assumptions and constraints—e.g.; in the project scope statement—can affect the schedule and what you can do about it.

Q2. List EEFs and OPAs that can influence the process of schedule development.

Once we have extracted this information from the input, we can transform it into a project schedule by using the tools and techniques listed in Table 5-7.

Applying Tools and Techniques for Schedule Development

Once you have the information talked about in the previous section in network diagrams for the activities, as well as the activity duration estimates, you are well equipped to start scheduling the project. Starting with network diagrams and activity duration, you move to put the information pieces together while dealing with issues like the following:

- The actual start date
- Uncertainty on the availability of resources
- Identification of and preparation for activities on the critical path
- Risks involved, or "what if" scenarios
- The hard start/finish dates for activities or for the project that came down the pipeline from very important stakeholders

In the following, we will show how to use various tools and techniques to address these and other issues or concerns while hammering out the project schedule.

Schedule Network Analysis

The schedule network analysis is a wrapper technique used to generate a project schedule model using multiple techniques, such as critical path method, resource optimization, and simulation models. All of these and more techniques are discussed in the following sections.

Critical Path Method

This is the schedule network analysis technique used to identify the schedule flexibility and the critical path of the project schedule network diagram. The critical path is the longest path (sequence of activities) in a project schedule network diagram. Because it is the longest path, it determines the duration of the project, and hence the finish date of the project given the start date. An example will explain this. Consider the network diagram presented in Figure 5-4. The boxes in the figure represent activities, such as activity A followed by activity B, and the number on top of a box represents the duration of the activity in time units, such as days.

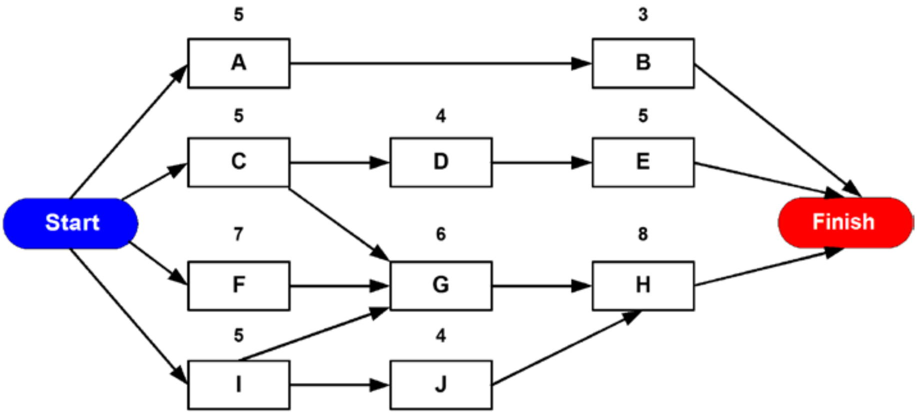


Figure 5-4. An example of a project schedule network diagram. The duration of an activity is represented by the number shown on top of the box that represents the activity.

Table 5-8 shows the calculations for the duration of each path of the network diagram by adding the durations of the individual activities on the path. You can see from Table 5-8 that the path Start-F-G-H-Finish is the critical path because it is the longest path in the diagram, at 21 days. This means if the project start date is January 2, the project finish date will be January 23—i.e., 2+21—given that the duration is shown in calendar time units.

Table 5-8. Path Durations Calculated from the Network Diagram Shown in Figure 5-4

Path	Durations of Activities	Path duration
Start-A-B-Finish	5+3	8
Start-C-D-E-Finish	5+4+5	14
Start-C-G-H-Finish	5+6+8	19
Start-F-G-H-Finish	7+6+8	21
Start-I-G-H-Finish	5+6+8	19
Start-I-J-H-Finish	5+4+8	17

The second important step of the critical path method is to identify the flexibility in the project schedule by calculating the early and late start and finish dates of each activity on each path. The schedule flexibility of an activity is measured by the positive difference between the late start date and the early start date for the activity; this is called *float time* or *total float*.

Table 5-9 shows calculations for the early and late start and finish dates and the float time for each activity in the network diagram being analyzed. The early start and finish dates of activities on a path are calculated by using the forward-pass method, which means you start your calculations from the start point (left-most) and make your way forward. As an example, consider the path Start-A-B-Finish in the network diagram shown in Figure 5-4. Because A is the first activity on the path, its early start is day 0. Because B depends on the completion of A, and A takes five days to finish, the early start date for B is the early start date of A plus the duration of A—that is, 0+5 = 5. The late start and finish dates are calculated using the backward-pass method, which means you start your calculations from the finish point. The project finish date determined by the critical path is day 21, given that the project start date is day 0. Because activity B has a duration of three days, it must be started no later than day 18 (21-3=18). Therefore, day 18 is the late start date of activity B. Activity A has a duration of five days, so, given that B must start on day 18, A must not start later than day 13; i.e., (18-5=13). Therefore, the late start date for A is day 13. The float times are calculated as follows:

Float time for A = late start - early start = 13-0 = 13

Float time for B = late start - early start = 18-5 = 13

Table 5-9. Early and Late Start and Finish Dates for Activities in the Network Diagram Shown in Figure 5-5

Activity	Early Start	Early Finish	Late Start	Late Finish	Float Time
A	0	5	13	18	13
B	5	8	18	21	13
C	0	5	2 (not 7)	12	2
D	5	9	12	16	7
E	9	14	16	21	7
F	0	7	0	7	0
G	7	13	7	13	0
H	13	21	13	21	0
I	0	5	2 (not 4)	9	2
J	5	9	9	13	4

Note that each of the activities on the critical path (F, G, and H) has a float time of zero. This obviously is a source of schedule risk.

Note Each activity on a critical path has zero float time, and therefore poses a schedule risk. Therefore, you must monitor the activities on all critical paths very closely during the execution of the project.

Resource Optimization

Resource optimization refers to optimizing the use of available resources to finish the project within the planned start and finish dates. This may be done by adjusting the activities' dates as shown in the following two example techniques.

Resource Leveling. Resource leveling is applied to the schedule that has already been analyzed using other methods, such as the critical path method, and hence we know the project start and finish dates, as well as start and finish dates and floats for activities. This techniques adjusts the start and finish dates of activities, using the already assigned resources to finish the project within the planned start and finish dates. The following are some examples of situations in which critical resources are being shared and thus where resource leveling may help:

- Resources are available only at specific times.
- Resources are available in limited quantities.
- Resources are assigned to multiple activities to be performed at the same time.
- Resources need to be used at a constant rate.

To deal with such situations, this technique adjusts the start and finish dates of activities by using the activity floats. In this interplay between activities and resources, a part of the resources from one activity may be assigned to another; hence, the name *resource leveling*.

Resource Smoothing. In this technique, like in resource leveling, you adjust the activities so as to finish the project within start and finish dates for given assigned resources by using activity floats. Unlike resource leveling, you cannot change the critical path of the project. What trick is possible? The key is the total float; you cannot change the start and end dates of the paths, but you can delay the activities within their free float and total float of the path.

Caution! Due to the change in the activity durations, resource leveling can result in a change of critical paths. Resource smoothing may not always optimize the use of resources.

Simulations and "What if" Scenario Analysis

In addition to the main techniques to develop the project schedule, which I already discussed, there are some other tools and techniques for developing the project schedule that I will discuss in this section.

"What if" Scenario Analysis. The purpose of "what if" scenario analysis is to calculate the effects of a specific scenario on the schedule—for example, how the schedule will be affected if a vendor does not make the delivery of a major component on the promised date. Because a "what if" scenario by definition represents uncertainty, this analysis often leads to risk planning, which might include changing the schedule or changing the network diagram to get a few activities out of harm's way if possible.

As you have seen, the critical path method is used to develop a schedule for given resources, whereas a method called the critical method that method factors in the uncertainty of the availability of the resources. The resource leveling technique is used to move the resources around to meet the resource needs of the activities that must be accomplished by a specific date. In other words, in an ideal world in which the required (or planned) resources are guaranteed, you do not need the critical chain method and resource leveling; just the critical path method will do.

Simulations. In any field, simulation models are used when calculable theory is not available or when dealing with a multitude of parameters and options that mean exact calculations are not feasible. Regarding the schedule, simulation models—e.g.; Monte Carlo models—are used to estimate the combined effect of all sources of uncertainty, or risk, on project objectives. When using the Monte Carlo model for this purpose, you can use multiple activity durations with different sets assumptions, constraints, and risks to simulate the combined effect and produce different affects.

Caution! The PMBOK levels simulations and "what if" scenario analysis as data analysis techniques. One may make the case that data analysis is also involved in other techniques discussed here.

Applying Leads and Lags

Just like in the activity sequencing process, leads and lags can be applied during the development of the project schedule. If you applied some leads and lags during the activity sequencing process, it is time to consider whether you need to adjust those. This adjustment might be necessary to create a realistic schedule.

Let's assume you have used the critical path method to determine the schedule for a project. You have also applied other techniques, such as the critical chain method and resource leveling. The final realistic schedule that you have come up with has an unacceptable project duration (the length of the critical path). What do you do? This is where the schedule compression technique comes to your rescue.

Schedule Compression

Schedule compression is an attempt to shorten the project schedule without changing the project scope. It may be necessary in order to deal with schedule-related constraints and objectives. It is true that you, the project manager, build the schedule through cold, hard mathematical analysis and you don't just accept whatever schedule goals come down the pipeline from elsewhere, such as from the customer or the project sponsor. However, once you have the schedule built through analysis, you can attempt to accommodate some critical stakeholder expectations or hard deadlines, such as a predetermined project finish date. I have already discussed one such method, called resource leveling, to accommodate hard deadlines for activities. In this section, I will discuss two more methods for schedule compression: crashing and fast tracking.

Crashing. This is a schedule compression technique in which cost and schedule tradeoffs are analyzed to decrease the project duration with minimal additional cost. A number of alternatives are analyzed, including the assignment of additional resources. Approving overtime is another example of crashing. This option may increase the cost.

Fast Tracking. This is a schedule compression technique used to decrease the project duration by performing project phases or some schedule activities within a phase in parallel that would normally be performed in sequence. For example, testing of a product can start when some of its components are finished, rather than waiting for the whole product to be completed.

Tip Crashing usually involves assigning more resources, hence increasing the cost. However, guard yourself against the misconception that additional resources will linearly improve the performance. For example, if one programmer can develop a program in eight days, it does not necessarily mean that two programmers will develop the same program in four days, because there will be overheads, such as the initial less-productive stage of the newly assigned resource, the time taken to reallocate the work, the interaction among the resources, and so on.

Agile Release Planning and PMIS

These two tools can be used to help present the project schedule and related items. Agile release planning refers to the release of a high-level schedule timebound with the product roadmap. This release only looks out into the near future, accommodating the ideas of iteration and product evolution. A project management information system (PMIS) that includes schedule software can be used to generate the schedule and schedule-related items, such as project network diagrams, bar charts, and histograms.

After you apply these techniques on information extracted from the input, you obtain the project schedule and related items, as will be discussed in the following section.

Output of the Schedule Development Process

The planned project schedule is an obvious output of the schedule development process. This and other output items are discussed in this list.

Project Schedule. The project schedule includes a planned start date and a planned finish date for each schedule activity. The schedule will be considered preliminary until the resources have been assigned to perform the activities according to the schedule. Although a schedule for a simple project might be presented in a tabular form, typically a project schedule is presented in one of the following graphical formats:

- **Project Schedule Network Diagram.** These diagrams present the schedule activities on a timescale with start and finish dates for each activity; hence, they show the dependencies between activities. Because they show the dependencies, which is the logic, they are also called *logic charts*.

- **Bar Chart.** In these charts, the activities are represented by bars, with each bar showing the start date, the finish date, and the duration of the activity. They are easy to read and are often used in presentations.
- **Milestone Chart.** These are typically bar charts representing only the milestones, not all the schedule activities.

Schedule Baseline. This is a specific version of the project schedule that is accepted and approved by the appropriate stakeholder, such as the project sponsor. This schedule baseline becomes part of the project plan. The actual project work results are compared against this baseline to measure the project's progress. Any proposed change to this baseline must go through standard change procedures—the Integrated Change Control process.

Project Calendars. These calendars contain information about work days, shifts, times of the days, and activities available for the project.

Schedule Data. This is the supporting data for the project schedule and consists of the following:

- Schedule activities, schedule milestones, activity attributes, and documentation of all identified assumptions and constraints
- Resource requirements by time period
- Alternative schedules—for example, schedules based on best-case and worst-case scenarios
- Schedule contingency reserves

Tip The schedule data may be enriched with items such as delivery schedules, order schedules, and resource histograms, depending on the nature of the project.

This data is used to create the baseline version of the schedule.

Change Request and Updates to Documents. Modification requests for project scope or schedule will generate change requests, which must be processed through the Integrated Change Control process. Because schedule development is an iterative process, over time the way the schedule is developed may change, so the schedule development plan will need to be updated. Also, schedule changes such as new activities may affect the cost, so

the cost baseline may need to be updated. Similarly, the project documents listed in the output column of Table 5-7 may need to be updated for changes obvious to figure out. For example:

- **Resource Requirements.** The schedule development process—e.g.; resource leveling—may change the initial estimate for the types and quantities of the required resources.
- **Activity Attributes.** Resource requirements or any other activity attributes that have changed must be updated during this process.
- **Assumptions Log and Risk Register.** During schedule development, the change in assumptions about activity durations, needed resources, and so forth may be revealed. This will cause changes to the risk assessment. Hence, the assumptions log and risk register will need to be updated.

Note Project schedule development is an iterative process. For example, it might be necessary to review and revise the duration and resource estimates for some activities to create a project schedule that will be approved. The approved project schedule will act as a baseline against which project progress will be tracked.

As mentioned earlier, the approved project schedule is used as a baseline to track the project's progress. To some extent, the schedule development (or modification) continues throughout the project execution as a result of the approved changes and the risk occurrences.

STUDY CHECKPOINT 5.6

Lora Nirvana is the project manager for the Sequence the DNA of a Buffalo (SDB) project. Match each item in the first column of the following table to the correct item in the second column.

Output of the Develop Schedule process	Description
A. Schedule data	1. A bar chart that includes all the activities of the project and also includes milestones. Lora points out this bar chart to the project sponsor to show where they are in the execution of the project.
B. Project document updates	2. A bar chart hanging on the calendar that has never changed once it was approved. Lora compares the current bar chart with this bar chart to show the progress.
C. Schedule	3. On a bar chart, Lora points to the dates when she will have the DNA sample isolated and purified, when she will get the DNA sample run through the genetic analyzer, when she will receive the results from the analyzer, and when the results will be published on the Internet.
D. Schedule baseline	4. After realizing that their chosen vendor has a track record of sending the DNA analysis kits late, Lora writes something into the risk register.

Once the schedule is developed and approved, it needs to be controlled throughout the lifecycle of the project.

Controlling Schedule

Schedule control has a three-pronged goal: 1) monitor the status of the project to see if it's progressing according to the planned schedule, and if it's not, 2) take action, such as changing resources or changing schedule; and 3) manage this change. As a project manager, you should be out in front of the project, performing the following tasks on regular basis:

- Determine the current status of the project schedule.
- Influence the factors that generate schedule changes.

- Determine whether the project schedule has changed—for example, if some activities are running late.
- Manage the changes as they occur.
- Detect or measure a schedule change by comparing the project execution results—i.e., work performance data—against the schedule baseline; both are major input items into the schedule control process, as shown in Table 5-10.

Table 5-10. The Control Schedule Process: Input, Tools and Techniques, and Output

Input	Tools and Techniques	Output
1. Project Management Plan: • Schedule management plan • Schedule baseline • Scope baseline 2. Performance measurement baseline 3. Project documents: • Project schedule • Schedule data • Project calendar • Resource calendars • Lessons learned register 4. Work performance data 5. Organizational project assets	1. Earned value analysis 2. Critical path method 3. Variance analysis 4. Iteration burndown chart 5. "What if" scenario analysis 6. Project management information system 7. Trend analysis 8. Resource optimization 9. Schedule compression 10. Leads and lags 11. Performance reviews	1. Work performance information 2. Schedule forecast 3. Change requests 4. Plan updates: • Schedule management plan • Schedule baseline • Cost baseline 5. Performance measurement baseline 6. Project document updates: • Project schedule • Schedule data • Resource calendars • Basis of estimates • Assumptions log • Risk register • Lessons learned register

Performing the Control Schedule Process

In the following, we explain the control schedule process in the form of its main steps.

Getting the Needed Information

To control the project schedule, you need to know what to expect from the project, which is given in the *schedule baseline*, and you need to know how the project is actually performing, which can be found in the *work performance data*. These are the core input items needed. Of course, as we are controlling the schedule, all the needed schedule-related items on the schedule appear in the input column of Table 5-10. You will control the schedule as planned in the *schedule management plan*, which also contains information about the usage of reserve and the allowed frequency of schedule updates. For other information about deliverables, assumptions, and constraints necessary with schedule control, we need the *scope baseline*.

Generating the Work Performance Information: Measuring Variance

In this process, we generate the schedule-related *work performance information* by comparing the schedule-related actual results in the *work performance data* against the *schedule baseline*. This comparison produces the variance of start and finish dates, and hence also the durations of the activities. The work performance information document has this information to the work-package level.

This information is produced by using one or often more of the techniques discussed next.

Earned Value Analysis. These techniques are used to calculate the schedule variance (SV) and schedule performance index (SPI) and are discussed in detail in terms of cost in an upcoming chapter on cost management. In this process, you use these quantities to assess the variation from the schedule baseline.

Variance Analysis. Performing a barebones schedule variance analysis, this technique is crucial to schedule monitoring because it reveals the deviation of the actual start and finish dates from the planned start and finish dates of schedule activities. It also reveals the variations of actual versus planned durations and floats. It might suggest corrective actions to be taken to keep the project on track.

Performance Reviews. Performance reviews are simple reviews of project progress that compare the performance data with the schedule baseline. These comparisons use start and end dates and percentages of completed and remaining work to analyze the variances.

Project Management Information System. The included schedule software can be used to generate the schedule and schedule-related items, such as project network diagrams, bar charts, and histograms. Since it already has the schedule-related information, it is able to provide the schedule variance (SV) information and also forecast the effect of this variance on the schedule model going forward.

Generating Schedule Forecast

Schedule forecasts are predictions of the future state of the project if it continues on the current path defined by the current schedule-related *work performance information*. Forecasts are based on trends extracted from current and past information. The variance analysis technique and PMIS also include the ability to forecast the effect of variances on the project's future. You can also use *trend analysis* techniques that compare the work performance data with the schedule baseline over time. One such technique in called an *iteration burndown chart*.

The iteration burndown chart technique works by keeping track of the remaining project work over workings days. A very simple example presented in Figure 5-5 illustrates this technique, where decreasing remaining work is plotted against the accumulating working days, called *iteration days*. The solid line represents the planned schedule in the baseline, which shows the project being complete in 40 days. The bullet points in the figure represent the performance data from the project execution. The dashed trend line drawn through these data points predicts that the project is on track to being completed in 47 days, a deviation or variance of 7 days.

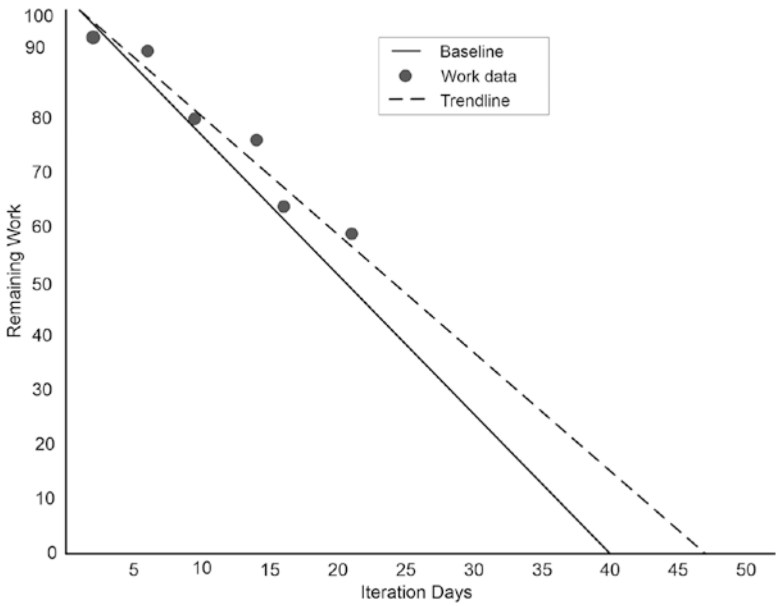


Figure 5-5. Iteration burndown graphs

After we find out that the project has gone off track by measuring the deviation in terms of variance, the question is how to get the project back on track—in alignment with the schedule baseline.

Bringing Project Back on Track: Generating Change Requests and Updates

Having measured the schedule variations from the schedule baseline, there are only two ways to put the project back on track: 1) align the project with the schedule baseline without updating the baseline; and 2) update the baseline.

Align the Project with Schedule Baseline Without Updating the Baseline. This can be done by using techniques already discussed while covering the schedule development process. The examples include resource optimization, schedule compression, lag and leads, and what-if scenario analysis.

Update the Schedule Baseline. A schedule baseline update is an obvious way to align the project schedule with the schedule baseline. You can use trend lines and future forecasts as a guide to updating the baseline. Before the schedule baseline updates can be applied, change requests will need to be created, which must go through the standard approval process. Schedule change request will also trigger other change requests, such as those to the cost baseline. Work performance information produced in this process may also create non–schedule related change requests as well.

As a result of these changes, some documents listed in the output column of Table 5-10 may need to be updated.

Caution! Since schedule variance on the critical or near critical path directly impacts the project finish date, mainly these paths determine the project status. Therefore, the activities on these paths should be closely watched; even a short delay for the critical path may produce a bigger effect on the project end date than bigger delays on non-critical paths.

Tip Remember that corrective actions are not about going back and fixing past mistakes. Rather, they're about ensuring that future results match with the plan. You can do this by influencing the future results, such as by expediting the execution or by changing the plan.

STUDY CHECKPOINT 5.7

Q1. Use your knowledge about the lessons learned register to figure out why we need it as input to the control schedule process.

Q2. Knowing the schedule control process, make a list of organizational process assets that will influence this process.

The three most important takeaways from this chapter are as follows:

- Various schedule management processes are used to produce schedule data—a list of schedule activities and attributes for each activity, such as activity duration, previous and following activity, and also the required resources, determined by a resource management process.
- The schedule data is used to develop the project schedule, which is an iterative process due to the uncertainties in the schedule data and due to the changes made during project execution. Nevertheless, the approved version of the planned schedule is used as a baseline to track the project progress.
- The schedule needs to be controlled to keep the project on the track—i.e., in alignment with the schedule baseline. The major output items of the schedule control process are work performance information, schedule forecasts, and change requests resulting from comparing the schedule-related work performance data with the schedule baseline.

Summary

Project schedule development is a journey that begins with decomposing the work packages in the WBS into project activities and ends with an approved schedule for performing those activities, called the schedule baseline. The schedule, once developed, needs to be controlled to keep the actual project execution in sync with this baseline. Of course, all the schedule-related processes are performed according to the schedule management plan developed before using these processes.

The Define Activities process is used to decompose the work packages in the WBS into activities with attributes available at the time; the activities would later be scheduled. The resulting activity list is used by the activity sequencing process to generate schedule network diagrams, which display the dependencies among the activities. The network diagrams are constructed using the precedence diagramming method (PDM) along with other techniques. The activity list and attributes are also used to determine the resource requirements for the project. Given the available resources, you can estimate the activity duration—that is, the time it will take to perform the activity.

All the pieces developed by these processes come together to develop the project schedule by using the Develop Schedule process via a host of techniques. You, for example, may start with using the critical path method to develop the project schedule from a network diagram. After you have this schedule, you can use schedule compression methods, such as fast tracking and crashing, to accommodate hard deadlines. Schedule development is an iterative process that can continue throughout the project execution due to approved changes and risk occurrences. However, the approved planned project schedule is used as a baseline to track the project's progress. You need to control the schedule to keep it aligned with the schedule baseline, which includes monitoring the status of the project's progress and controlling the changes to the schedule baseline.

Road Ahead. The duration is an important attribute of an activity, as the schedule directly depends upon it. The duration is estimated for the given resources available for the activity. In the next chapter, we will discuss the process to estimate the activity resources along with other resource management processes.

Exam's Eye View

Comprehend

- The schedule management plan is developed from the project charter, scope management plan, and the product development approach and is used as an input to all other project schedule management processes.
- The major task of the Define Activities process is to generate the activity list by decomposing the work packages in the WBS into activities.
- The major task of the Sequence Activities process is to determine the dependencies among the activities in the activity list, sequence them accordingly, and display that sequence in the network diagrams.
- Network diagrams with activity durations assigned to each activity can be used to develop the schedule.
- We need to know the activity resource requirements to estimate the duration for an activity.

Look Out

- Because deliverable are broken down into work packages and activities in progressive elaboration fashion, it may generate change requests to update scope and cost baselines.
- One main advantage of sequencing activities is that it is a way to handle project constraints in the most efficient manner.
- Activity duration is estimated for a given resource committed to the activity. Changing the quantity or capability of the resource will change the duration estimate.
- Each activity on a critical path has zero float time and thus poses a schedule risk. Therefore, you must monitor the activities on all critical paths very closely during the execution of the project.
- The approved version of the project schedule is called the project schedule baseline, against which the project's progress is tracked and measured by comparing the actual progress with the baseline.

Memorize

- Project mile schedule, an output of Define Activities, comes from the WBS dictionary, a component of the scope baseline.
- Dependencies have four attributes: internal mandatory dependencies, external mandatory dependencies, internal discretionary dependencies, and external discretionary dependencies.
- In PDM, finish-to-start is the most commonly used dependency relationship, whereas start-to-finish is the least used.
- Activity duration measured in work periods does not include holidays, whereas the duration measured in calendar units does. For example, the activity duration from Friday to the following Tuesday is three days when measured in work units and five days when measured in calendar units, given that no work is done on Saturday and Sunday.
- The approved project schedule, called the schedule baseline, becomes part of the project management plan.
- Fast tracking compresses the schedule by performing activities simultaneously that would otherwise be performed in sequence, whereas crashing compresses the schedule by assigning more resources.
- The schedule control process, by comparing the schedule-related work performance data with the schedule baseline, produces the work performance information containing schedule variance, i.e., deviation from schedule baseline, and schedule forecasts based on this and past performance.

Review Questions

1. Which of the following is the most commonly used network diagramming method?
   A. Critical path method (CPM)
   B. Simulations
   C. Precedence diagramming method (PDM)
   D. Arrow diagramming method (ADM)
2. What is the crashing technique used for?
   A. Schedule Network diagramming
   B. Duration compression
   C. Cost reduction
   D. Activity sequencing
3. Which of the following is a true statement about the critical path?
   A. Each activity on the critical path has zero float time.
   B. It controls the project finish date.
   C. It controls the project start date.
   D. It is the shortest sequence in the network diagram.
4. In your research project on tourism, you must collect data before the tourist season ends because the project involves interviewing tourists. The data-collection activity has which of the following kinds of dependency?
   A. Mandatory
   B. External
   C. Internal
   D. Internal discretionary
5. You know from a network diagram that Activity B cannot start until Activity A is finished. Which of the following are true?
   A. Activities A and B have a start-to-finish dependency.
   B. Activities A and B have a finish-to-start dependency.
   C. Activity B has a mandatory dependency on Activity A.
   D. Activities A and B are on a critical path.

6. Why should you monitor the activities on the critical path more closely?

   A. Because each activity on the critical path has a zero float time and thereby poses a schedule risk.

   B. Because the activities on the critical path need to be performed before the activities on other paths.

   C. Because the activities on the critical path are critical to the organization's strategy.

   D. Because the activities on noncritical paths depend upon the activities on the critical path.

7. You estimate the duration of an activity as five days because an expert told you that it took five days to complete a similar activity in a previous project. Which of the following methods might the expert be using for this activity duration estimate?

   A. Parametric estimating

   B. Expert judgment

   C. Analogous estimating

   D. Delphi technique

8. You have developed the schedule for your project, and you've called the kickoff meeting. A team member who is responsible for an activity comes to you and tells you that the activity cannot be performed within the allocated time because some pieces were left out during activity definition. The revised estimate will add two more days to the activity duration, but the activity is not on the critical path. Which of the following actions will you take?

   A. Go to the team member's functional manager and find out whether the team member's estimate is correct.

   B. Accept the new estimate but do not change the schedule.

   C. Accept the new estimate and update the schedule accordingly.

   D. Put the new estimate through the integrated change control process.

9. The amount of time by which an activity can be delayed without changing the project finish date is called:

   A. Float time

   B. Lag time

   C. Grace time

   D. Activity gradient

10. You are the project manager of a project that is running behind schedule. The project sponsor is very unhappy at the new finish date that you proposed, but he has accepted it. However, you also requested extra funds to support the extended time of work, and the sponsor has refused to supply more funds and is threatening to cancel the project if you cannot finish the project within the planned budget. What are your options?

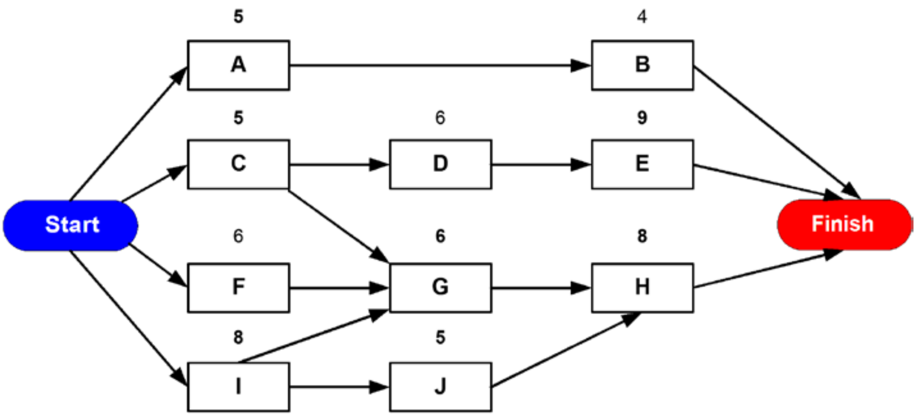
    A. Crashing

    B. Fast tracking

    C. Asking the executive management for a new sponsor

    D. Speaking with the customer directly without involving the sponsor to see whether the customer can increase the budget

11. Consider the following network diagram. Which of the following is the critical path?



A. Start-C-D-E-Finish

B. Start-I-G-E-Finish

C. Start-I-G-H-Finish

D. Start-I-J-H-Finish

E. Start-I-G-H-E-Finish

12. What is the float for Activity G in the network diagram in Question 11?

A. 3

B. 2

C. 1

D. 0

13. What is the length of the critical path in the network diagram shown in Question 11?

A. 4

B. 6

C. 22

D. 5

14. You use a three-point estimate for activity duration estimating. An activity has a duration of 9 days for an optimistic scenario, 18 days for a pessimistic scenario, and 12 days for the most-likely scenario. Which of the following will you take as the duration estimate if a weight of 4 is assigned to the most-likely scenario as compared to a weight of 1 for each of the optimistic and pessimistic scenarios?

A. 13 days

B. 12.5 days

C. 12 days

D. 18 days

15. Which of the following is not an input item to the Define Activities process?

    A. The WBS

    B. The activity duration

    C. The project scope statement

    D. The WBS dictionary

16. Which of the following is not an output of the schedule control process?

    A. Recommended corrective actions

    B. Updates to the schedule baseline

    C. Schedule variations

    D. Work performance data

17. The project charter is an input to which schedule management process?

    A. Define activities

    B. Sequence activities

    C. Plan schedule management

    D. Schedule development

CHAPTER

6

Project Resource Management

The objectives covered in this chapter make up 8 percent of the CAPM exam, equivalent to about 11 questions. Study the whole chapter in detail.

It's enough to just remember the name of the input, tools and techniques, and outputs. You should know what is in a given input item that the given process uses and how that helps in generating the output, as well as what a given tool or technique does in a given process.

You should be very clear about organization charts—e.g.; an organizational breakdown structure—assignment matrix, five general techniques for managing conflict, and so forth.

While studying this knowledge area and its processes, pay attention to how the tasks can be tailored and adapted to your needs, and recognize an agile environment in action; for example, continual assessment generates change requests which lead to changing plans—i.e., adapting.

P. Sanghera, *CAPM® in Depth*, https://doi.org/10.1007/978-1-4842-3664-2_6

CAPM Exam Objectives

Project Resource Management:

1. Define the six project management processes in the project resource management knowledge area.
2. Identify the input, tools and techniques, and outputs defined in the six processes in project resource management.
3. Identify key concepts and trends in project resource management, including tailoring and special considerations for agile/adaptive environments.
4. Identify techniques for developing a team, managing conflict, and resolving resource-related problems.
5. Understand the components of a resource management plan and data representation techniques for managing project resources.

Executing a project requires resources, and executing a project successfully requires the optimal use of those resources. Therefore, coordinating and managing resources, including both human resources—also called team resources—and physical resources—i.e., material, equipment, facilities, and infrastructure—is an integral part of overall project execution. Identifying, acquiring, and managing these resources is called *resource management*. During project planning, you define roles and assign responsibilities to those roles, as project work is generally performed in the form of roles and responsibilities. Project roles, responsibilities of the roles, and reporting relationships among the roles need to be determined in order to perform a project. This is accomplished during the development of the resource plan. The roles need to be filled with qualified individuals. A team is a group of individuals who perform individual responsibilities and work interdependently on their independent assignments. From a scientific viewpoint, a team is a dynamic entity, and its dynamics are determined by the interaction among its members. Therefore, for the team to be successful, it has to be effective in both dimensions: its members must be competent in performing their individual assignments, and the interaction among them must be constructive overall. To ensure that, you need to continually develop and manage the project team. To obtain the right individuals for the project team and to develop and manage the team is an art, whereas an effective team's making the project a success is a science that will unfold itself automatically if you do the art part right.

So, the core question in this chapter is how to build and manage a high-performance project team and optimize both team and physical resources by using resource management. In search of an answer, we will explore three avenues—developing the resource management plan, managing team resources, and managing physical resources.

Resource Management: Big Picture

In Chapter 5, you learned about creating and managing the project schedule. To implement that schedule, you need resources, which are managed by project resource management, whose big picture is illustrated in Figure 6-1. The processes in gray boxes in this figure are external to resource management.

As shown in Figure 6-1, the Estimate Activity Resources process, a resource management process, generates activity resource requirements, which are an input to the Develop the Project Schedule process, which in turn is used to estimate cost. The cost estimate is an input back to the Estimate Activity Resources process, and also an input to Determine Budget, which generates the cost baseline that is an input to Acquiring Resources. Note here the close connection between resource management and cost management.

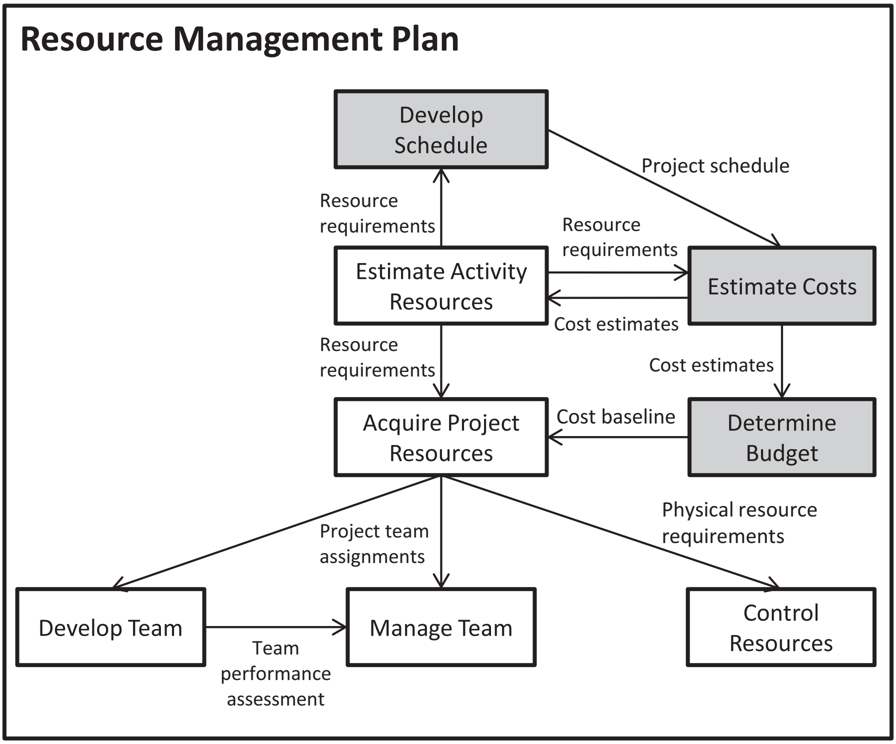


Figure 6-1. Big picture of resource management; processes shown in gray boxes are external to resource management

In resource management, first, the resource management plan is generated from the project charter, project scope baseline, and requirement documentation, and then becomes input to all other processes. After creating the resource management plan, you identify and estimate team and physical resources;

acquire resources; develop and manage the team resources, and control the physical resources. You do that using following processes:

- **Plan Resource Management.** This process is used to develop the resource management plan, which identifies the project roles, assigns responsibilities to these roles, and provides guides to how to perform the rest of the resource management processes.
- **Estimate Activity Resources.** Estimates the types and amounts of team and physical resources that will be required to perform each schedule activity. Physical resources are non-human resources such as facilities, equipment, material, and supplies.
- **Acquire Project Team.** The process of obtaining the team and physical resources estimated by the preceding process.
- **Develop Team.** The process of developing an optimal team by improving the individual competencies and interactions among the individual team members, thereby improving the team environment.
- **Manage Project Team.** The process of optimizing the team—hence, project performance—by tracking the performance of and providing feedback to the individual team members, managing changes related to the team, and resolving issues.
- **Control Resources.** The process of keeping planned, assigned (i.e., allotted), and used physical resources synchronized by ensuring that they are allotted, used, and released immediately after use.

Note As shown by Figure 6-1, resource management and cost management are closely connected. Also, the project team is a subset of the project stakeholders, so there is obviously an overlap between resource management and stakeholder management. You will notice that when we cover stakeholder management in the next section of this book.

Table 6-1 lists the processes of resource management along with their process groups and major output.

Table 6-1. Processes of Resource Management Mapped to the Process Groups

Resource Management Process	Process Group	Major Output	Performed
Develop Resource Plan	Planning	Resource management plan	Once or at predefined points in the project
Estimate activity resources	Planning	Resources requirement	Throughout the project
Acquire resources	Executing	Project staff assignments	Throughout the project
Develop Project Team	Executing	Team performance assessments	Throughout the project
Manage Project Team	Executing	Change requests	

Resource management processes will be performed according to the resource management plan.

Developing the Resource Plan

First, in order to avoid confusion, you must understand the logical relationships among the project, team resource requirements, roles, and responsibilities as illustrated in Figure 6-2. Roles are determined by the resource requirements, and responsibilities are assigned to the roles to perform the project activities. In a nutshell, project work is generally performed in the form of roles and responsibilities. Project roles, responsibilities of the roles, and the reporting relationships among the roles need to be determined in order to perform a project. The use of the concept of *role* is that we can talk about it during planning even before hiring a person who will play this role. So, a role is a defined function to be performed by a team member, such as a programmer or tester. The other issue that needs to be addressed before the project can be performed is how and when the project team members will be acquired. The resource planning process addresses these issues.

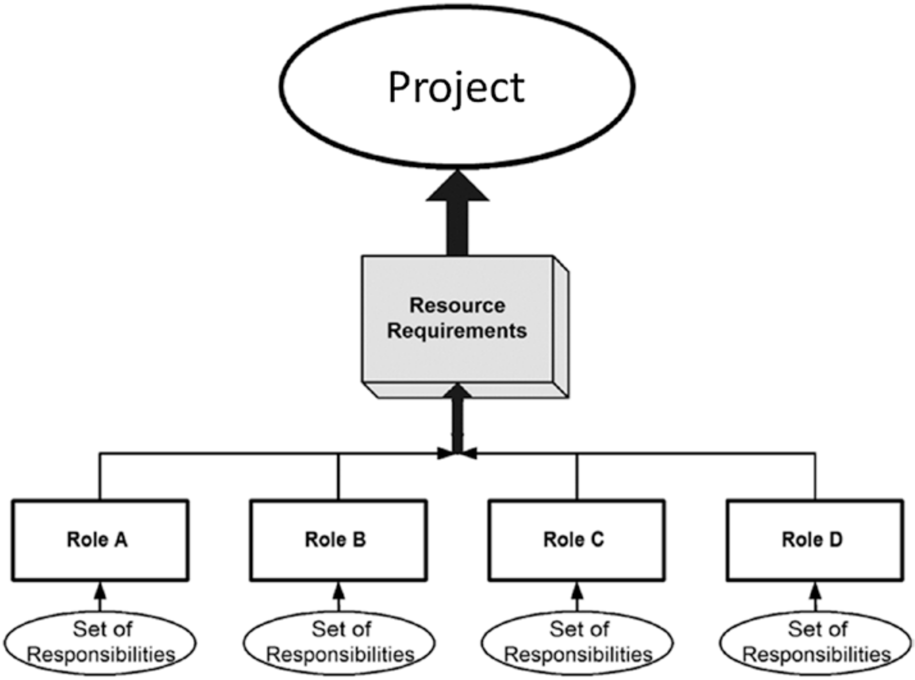


Figure 6-2. Relationship among project, project activity resource requirements, roles, and responsibilities

Therefore, two of the main goals of the resource planning process are the following:

- Identify and document project roles, responsibilities for each role, and reporting relationships among the roles.
- Develop the team resource management plan.

All this planning will go into a document called the resource management plan, which is developed by the Plan Resource Management process illustrated in Table 6-2 in terms of input, tools and techniques, and output.

Tip The main goal of the Plan Resource Management process is to develop a document that will answer the question: How do you identify the right resources in just the right amount and manage them for the successful completion the project?

Table 6-2. The Plan Resource Management Process: Input, Tools and Techniques, and Output

Input	Tools and Techniques	Output
1. Project charter 2. Project Management Plan: • Quality management plan • Scope baseline: scope statement, WBS, WBS dictionary 3. Project document: • Project schedule • Requirement document • Risk register • Stakeholder register 4. Enterprise environmental factors 5. Organizational project assets	1. Data representation • Hierarchical charts • Responsibility matrix • Text-oriented formats 2. Organization theory 3. Expert judgment 4. Meetings	1. Resource management plan 2. Team charter 3. Project document updates: • Assumptions log • Risk register

Generating Resource Management Plan

In order to devise an approach for how to identify and manage resources, we need to know what kind of resources we are talking about. This information can be derived from the project requirements. So, the following are the main steps one can take to generate a resource management plan by extracting project requirements and related information from the input of this process.

Core Resources Information. Get this information from the *requirement documentation* as it will largely determine the kind and amount of resources needed for the project. It may also suggest how to manage those resources. Also, get information about preapproved financial resources from the *project charter*, which also contains a high-level description of the project and other requirements, as well as a summary of milestones. From this info, you can not only derive the resource requirements, but also how to manage those resources.

Go to Root of Resources Requirement. Get information about deliverables from the scope baseline, from which information regarding the kinds and amount of needed resources and how to manage them can be derived. Also, the *quality management plan* contains info about the kind of resources needed to implement the required quality and the level of resources to maintain it. You use this information for two purposes: 1) to check on the information in the *requirement documentation*, and 2) to derive new resource requirements.

What Will Impact Resources? Get information about threats and opportunities from the *risk register*, which may impact the need, availability, and management of resources. Also check into the *stakeholder register* to identify stakeholders who can impact the different aspects of the resources, such as the kinds and availability of resources.

Generate Resource Management Plan. Use data presentation and other techniques to generate resource management plan.

Tools and Techniques for Resource Planning

At the heart of resource planning lies the art of converting the information about work packages or related activities and activity resource requirements into roles and responsibilities. For example, consider an activity in a project—writing a software program. The program will be written by a programmer, which is a human resource, in this case a team resource. However, before you even know the name of the programmer, for planning purposes you can work with this programmer as a role whose main responsibility is to write the program, later assigning a real individual to fill this role. This approach allows for planning before hiring. The tools and techniques used in creating the resource management plan, including determining the roles for the project, are discussed in the following.

Data Presentation Techniques. These techniques can be used to identify, document, and communicate the roles of the project team members, the responsibilities assigned to the roles, and the relationships among the roles. The most popular way to implement these techniques is in the form of charts, which can fall into three categories—hierarchical, matrix, and text oriented.

Tip Hierarchical techniques are suitable to represent high-level roles, while text formats can be used to describe the responsibilities in detail.

- **Hierarchical.** Hierarchical charts are the traditional way to represent the reporting relationships in an organization in a top-down format. Such a chart is also called an *organizational breakdown structure (OBS)* and is arranged according to the organization's existing departments, units, or teams. The OBS approach used in resource management will list project work packages or related activities, as well as team members with their roles and responsibilities for the project under each department. We have already explored another hierarchical chart called WBS in the chapter on scope management. Recall

that WBS breaks down deliverables into work packages, which can be used to show responsibilities at a high level.

Another type of hierarchical chart is called the resource breakdown structure (RBS), which starts by dividing the team and physical resources into different categories and breaking them down further, providing increasingly more detail at each lower level. The idea is to break them into small enough pieces such that they can be assigned to work packages or related activities in the WBS. The RBS will be covered in the next section of this chapter.

- **Assignment Matrix.** This matrix is used to specify the relationships between activities or work packages, roles for performing those activities, and team members assigned to the roles. Such a matrix is generally called a *responsibility assignment matrix (RAM)*. Different matrices can show these relationships at different levels. For example, you can use the RAM to document resource requirements for each activity, as shown in Table 6-3. For example, the second row of Table 6-3 says it will take six developers, six workstations, and one server to perform activity B. You can also use RAM to document the specific responsibilities assigned to specific team members for the schedule activities, as shown in Table 6-4.

Table 6-3. An Example of a Responsibility Assignment Matrix (RAM) Depicting the Resources Required to Perform Schedule Activities

Activity	Designer	Developer	Tester	Marketer	Workstation	Server
A	1					
B		6			6	1
C			3		3	2
D				2		
E	1	1	1		1	

Remember that the RAM can be used for various purposes at various levels. While the RAM in Table 6-3 documents the resource requirements for the schedule activities, the RAM in Table 6-4 depicts the roles of team members with responsibilities for schedule activities and is called a RACI chart, where RACI stand for *responsible, accountable, consult, and inform*.

- **Text-Oriented Formats**. These formats are useful when the team members' responsibilities need to be described in greater detail. A text-oriented chart may include information about role responsibilities, authority, competencies, and required qualifications. In the real world, these charts are known by different names, such as job description and job responsibilities.

Caution! Information about some responsibilities of the resources will be scattered across the project management plan. For example, the risk register lists the risk owners, and the communication management plan lists individuals responsible for some types of communications, such as status reports.

Table 6-4. An example of a Responsibility Assignment Matrix (RAM) Depicting the Roles Assigned to the Team Members for Various Activities. Letters Are Used as Symbols to Represent Roles: R for Responsible, A for Accountable, C for Consult, and I for Inform.

Activity	Susan	Cathleen	Pappu	Maya	Kiruba
Design	R	A	I	I	C
Develop	I	I	R	I	C
Test	C	R	A	I	C
Deploy	I	I	A	I	R

The RAM in Table 6-4 is also called the *RACI chart* because it assigns four roles to team members for various activities: responsible (R), accountable (A), consult (C), and inform (I). For example, Susan has the responsibility of designing the product, Cathleen will be held accountable for the design, Kiruba will play the role of a consultant for designing the product, while Pappu and Maya will play the role of keeping everybody informed of the status and progress.

Tip Each activity or task should have an owner who is responsible for its successful completion. For complex tasks and activities there may be more roles assigned to it, but there must be only one principle owner. Joint ownership usually gives rise to confusion, finger pointing, conflict, more overhead, and dilution of commitment.

Organizational Theories. Various organizational theories provide information and insight on how people behave in a team or an organization, what motivates team members, and the like. If you have knowledge of these theories, it will help you plan resources quickly and more effectively. By understanding organizational theories, you can also comprehend why different organizational structures support different kinds of relationships among the organization's members and different kinds of responses to the same situation.

To summarize, data presentation techniques such as those in hierarchical and text-oriented form, as well as organizational theories, are the main tools and techniques used to develop the resource management plan. Of course, you can seek expert judgment on relevant topics, such as obtaining the best sources of talent management and complying with government, organizational, and union regulations. You will also be holding meetings for the resource management plan.

The Resource Management Plan

The results of your efforts in resource management planning—the output of the Plan Resource Management process—consist of a resource management plan and team charter documents, described next.

Resource Management Plan

This document describes how to identify, obtain, manage, and release the project resources, both human and physical. It categorizes them and describes roles and responsibilities, reporting relationships among the roles, and skills required to complete the project activities. The following are the main elements of this document.

Identifying and Acquiring Resources. This plan recommends the methods and ways to identify and obtain the right team and physical resources for the project.

Roles and Responsibilities. This component contains roles and the responsibilities assigned to each role. The schedule activities will be completed by individuals working in certain roles and performing responsibilities that come with those roles. So, roles and responsibilities are an important part of resource management planning. While determining roles and responsibilities, you must be clear about the following concepts:

- **Role.** In real life, most activities are performed by people playing certain roles, such as a parent, a teacher, or a student. Similarly, in project management, a role is essentially a set of responsibilities, such as the responsibilities of a developer, a tester, or a manager. A role

is assigned to a team member, who will perform the responsibilities included in the role to complete one or more project activities.

- **Responsibility.** A responsibility is a piece of work (task) that must be performed as part of completing a project activity. Responsibilities can be grouped together as a role or assigned to a role.
- **Competency.** Competency is the ability of a team member to play a certain role—that is, to perform the responsibilities assigned to the role. While assigning a role to a team member, you should know whether the team member possesses the skills required to perform the responsibilities of the role. You need to respond to a mismatch with training, hiring, schedule changes, or scope changes.
- **Authority.** Authority is a right assigned to a role that enables the person playing the role to do certain things, such as to apply project resources, make certain decisions, sign approvals, or accept a completed deliverable. A person with authority obviously can influence the team work for the project. Poorly defined or undefined authorities can cause confusion and conflicts.

Tip Roles must be clarified by specifying the responsibilities and the authorities assigned to each role. A good match between the levels of responsibility and authority for each team member generally produces the best results. This gives the team members a sense of ownership. If you own it, you will less likely break it.

In a nutshell, human or team resource planning accomplishes two main things: it determines roles with responsibilities to perform the activities, and it guides how to fill those roles with team members.

Project Organizational Charts. A project organizational chart displays the project team members and the reporting relationships among them. The level of formality and detail of these charts depend upon the size and needs of the project at hand.

Team Resource Management Plan. This component of the resource management plan recommends how to manage the team resources: identify roles, acquire the staff to fill those roles, manage resources or team, and release the resources. After you have determined the roles to perform the activities, you need to identify individuals to fill those roles. The team resource management plan describes when and how human resource requirements for a project will be met. This component of the plan can include items such as the following:

- **Training Needs.** If some team members lack the adequate level of skill needed for the project, a training plan can be developed as part of the project. General approach or strategies are provided on this.
- **Team Development.** Methods of team development are recommended.
- **Recognition and Rewards.** Recognition and rewards are good tools used to promote and reinforce desired behavior. However, to use these tools effectively, you must have clear criteria for rewards based on the activities and performance of team members. The potential candidate for a reward must have an appropriate level of control over the activity for which the reward will be offered. For example, if a team member is to be rewarded for completing the project within the budget, the team member must have an adequate level of control over the decision-making that affected the spending.

Team Charter

The purpose of the team charter document is to record the team operating guidelines and rules to make the team effective. To that end, it includes items such as communicating and meeting guidelines, conflict-resolution process, decision-making process, and team values and agreement.

To make this document more effective, you should consider the following:

1. This document should make clear what behavior is expected from the team members.
2. The ground rule should be set up very early on for the smooth functioning of the team.
3. If the whole team participates in developing the team charter, it would be easier to implement it.

4. The charter should be reviewed from time to time to ensure continued and collective understanding.
5. It should be made available to new members right away as part of the team orientation.

STUDY CHECKPOINT 6.1

Use your knowledge of the Plan Resource Management process to answer the following questions:

Q1. List some EEFs that can influence the Plan Resource Management process.

Q2. List some OPAs that can influence the Plan Resource Management process.

Q3. How can the assumptions log and risk register project documents be updated as a result of this process?

Implementation of the resource management plan starts with estimating the resource requirements for project activities.

Estimating Activity Resources

In the previous chapter, we estimated the activities' durations given resource requirements, which we cover here. The resource requirements for project activities are estimated using the Estimate Activity Resources process. The main purpose of this process is to identify and estimate the following about both human and physical resources needed for each project activity:

- Features
- Types
- Quantities

Table 6-5 shows the Estimate Activity Resources process in terms of its input, tools and techniques, and output.

Table 6-5. The Estimate Activity Resources Process: Input, Tools and Techniques, and Output

Input	Tools and Techniques	Output
1. Project Management Plan: • Resource management plan • Scope baseline: scope statement, WBS, WBS dictionary 2. Project document: • Activity list • Activity attributes • Resource calendars • Cost estimate • Assumptions log • Risk register 3. Enterprise environmental factors 4. Organizational project assets	1. Bottom-up estimating 2. Parametric estimation 3. Analogous estimation 4. Alternatives analysis 5. Project management information systems 6. Expert judgment 7. Meetings	1. Resource requirements 2. Basis of estimate 3. Resource breakdown structure 4. Updates to project documents: • Activity attributes • Assumptions log • Lessons learned register

The first step in estimating activity resources it to collect data—i.e., the relevant information from the input items in the Estimate Activity Resources process.

Raw Data for Estimating Activity Resource Requirements

As a first step toward estimating resource requirements of the project at the activity level, collect the information about resources from the input items listed in Table 6-5.

Identification, Quantity, and Needed Resources. Collect the information from the *resource management plan* on how to identify and quantify the resources needed to do the project work. This plan also reveals how to aggregate this information into document(s). Get high-level information about the team of physical resources needed for the project from the *project scope*.

Activity-Level Resource Information. Check out the *activity list* to know what activities need resources. You can derive the human and physical resource needs of each activity from its attributes, such as resource requirements, required start and finish dates, activity location, and assumptions and constraints. This information is found in *activity attributes*.

Resource Information from Resource Calendars. Get the team and physical information from *resource calendars*. From there, you can possibly extract the information at both the activity and attribute levels, such as type of resources, quantity, skill level, experience, and geographical location. Typically, the resource calendar also contains the following useful information:

- Days and times of day when a resource is available
- The passive time for the resource—for example, holidays for human resources
- The quantity of each type of available resource
- The capability of each resource

Cost, Risk, and Information. Cost information about the resources may be extracted from the *assumptions log* and *cost estimates*, and risk information for each resource from the *risk register*. This cost and risk information would be useful when selecting the resources by some analysis technique such as alternative analysis.

You should also consider EEFs and OPAs, such as the following, which can influence activity resource estimation.

Enterprise Environmental Factors. Information about the infrastructure of the performing organization, such as existing facilities, will be used in identifying the resources and their availability. In addition to market conditions and published estimation data, organizational culture, resource location, and in-house skills would be important EEFs to consider.

Organizational Process Assets. The organizational process assets relevant to activity resource estimating include organizational policies for staffing and purchase of supplies, and historical information on what types of resources were used for similar activities in a previous project.

With this information, you can estimate activity requirements and aggregate then into a resource breakdown structure (RBS) with the help of tools.

Tools and Techniques for Activity Resource Estimating

Depending on which aspect of resource estimation you want to explore and in what detail, you can use one or more of the following tools and methods.

Analogous Estimation. This method is used for quick estimation in various situations, such as enough detailed activity information is not available so you can figure out only a couple of top levels of WBS, or there is an immediate need for a rough estimate before you get into making the accurate detailed

estimate. This method estimates resource requirements based on information from similar projects performed in past.

Bottom-up Estimating. You might discover that it is rather complex to estimate resources at the work-package level or even at the activity level. In that case, it might be helpful in certain cases to start at the activity level and decompose activities into even smaller components if need be for the purpose of resource estimating, then estimate the resources for each component, and then aggregate the resources to get an estimate for the whole activity. You can continue this aggregation to reach the package, control account, and summary levels of WBS. In aggregation, you must consider the possible relationships (overlaps and such) among different components of the activity so you don't double-count the resources.

Parametric Estimating. This method makes resource estimates from given data using parameters. For example, it's known it took 15 days to repair one mile of road for 10 workers, so under the same conditions it would take 20 workers to repair 2 miles of road in 15 days. The implementation of the technique generally includes statistical methods.

Alternative Analysis. Alternative analysis is all about exploring different solutions to a problem. In the case of estimating resource requirements, you will need to consider alternatives available for the resources needed for some activities. For example, you might need to decide whether you want to buy or develop a tool needed to perform an activity, what types of machines (for example, Windows or Linux) to use, which computer technology to use to do the development, or what level of skill is needed. Cost information and experience can come in handy here.

Of course, make use of expert judgment for resource planning and estimating and for team training.

Published Estimating Data. Information published by various vendors, such as costs for resources, can be useful in estimating the resources.

Project Management Software. Depending upon the sophistication of the resource requirements and the capabilities of the available features, project management software might be useful in estimating and managing the resources. It can also be used to create resource breakdown structures.

You can use a combination of these tools and techniques to generate the output of the resource estimating process. You should also be holding meetings with the team and other relevant stakeholders as the need arises.

Output of Activity Resource Estimating

The resource requirements are the major output of the resource estimating process. These and other output items are discussed in the following list.

Activity Resource Requirements and Basis of Estimation. The main purpose of the Activity Resource Estimating process is to determine the resource requirements for each activity, and therefore this is the major output item from this process. In this document, you identify the types of resources required to perform each activity and also the estimated required quantity of each identified resource. If a work package in the WBS has multiple activities, the resource estimates for those activities can be aggregated to the resource requirements for the work package; then, continue this aggregation to reach the control accounts and project summary levels of WBS.

The requirement documents may also include information such as the basis for each estimate, including methods, assumptions made, known risks and constraints, and resources used to make the estimates.

Resource Breakdown Structure. The resource breakdown structure (RBS) is a hierarchical structure of resource categories and types required to complete the activities of the project. The RBS can be used to identify and analyze the project team resource assignments and usage of physical resources.

Updates to Project Documents. The identified types of required resources for an activity and the estimated quantity of each identified resource become *activity attributes* and must be added to the activity attributes document. The activity resource estimating might generate modifications to the *activity list*—for example, to add or delete an activity. Moreover, new and changed assumptions and constraints will update the assumptions log, and you will update the lessons learned register with lessons; for example, which methods were more efficient and effective than others in resource estimation.

After we figure out project requirements, it's time to acquire the resources, both physical and human.

Acquiring Project Resources

Project resources, both team and physical, are obtained and selected using the Acquire Resources process, shown in Table 6-6 in terms of input, tools and techniques, and output. The project work will be executed by the project team, and therefore the role of the team in the success of the project is crucial. It is critical to acquire the right project team for your project. Roles and responsibilities for the roles required to complete the project are defined during the resource planning process, discussed earlier in this chapter. Before the work can start, the roles need to be assigned to real individuals, who will become the members of the project team.

Table 6-6. The Acquire Resources Process: Input, Tools and Techniques, and Output

Input	Tools and Techniques	Output
1. Project Management Plan: • Resource management plan • Procurement management plan • Cost baseline 2. Project documents: • Project schedule • Resource requirements • Resource calendars • Stakeholder register 3. Enterprise environmental factors 4. Organizational project assets	1. Decision making: • Multicriteria decision analysis 2. Interpersonal and team skills: • Negotiations • Pre-assignments • Virtual teams	1. Physical resource assignments 2. Project team assignments 3. Resource calendars 4. Project Management Plan updates: • Resource management plan • Cost baseline 5. Updates to project documents: • Project schedule • RBS • Resource requirements • Stakeholder register • Risk register • Lessons learned register 6. Enterprise environmental factors 7. Organizational project assets

Selecting and Assigning Resources

The goal and output of the Acquire Resources process is resource assignments. You just don't want to assign any resources to your project, but only the best available. So, selecting the right resources is a crucial part of this process. In the following, we explain in the form of steps how to perform this process:

1. **How? Questions**. Get general information about how to acquire resources from the *resource management* plan, and what resources will be procured and how to integrate them with the project and its stakeholders from the *procure management plan*.

2. **Resources Needs**. Fetch information about the project resources that need to be obtained from the *resources requirements* document, and also from the *stakeholder register*, where you may find stakeholders' requirements or expectations about the use of specific resources; for example, they want to use Apple computers instead of Windows.
3. **Resources Use Time**. Obtain information from the *project schedule* about when a given kind of resource is available; for example, ten software engineers are needed for the months of March and April.
4. **Resources Availability**. In light of the information from steps 2 and 3, look into *resource calendars* to find out what resources are already available in what time slots.
5. **Select and Acquire Resources**. Select and obtain the needed resources that are not currently available by using the techniques listed in Table 6-6. While selecting resources, cost information from the *cost baseline* will be useful.
6. **Resource Assignments**. After having selected and obtained team and physical resources, assign them to the project and record these assignments into the *team resource assignments* and *physical resource assignments* documents, respectively. Of course, these assignment records will contain the appropriate details, such as name, time, and role and responsibilities that come with the roles. These two documents make up the output of this process.
7. **Create or Update Resource Calendars**. Log the assignment information into the *resource calendars,* another output of this process. Create them if they do not already exist.
8. **Create Change Requests**. During the performance of this process, the need for a corrective action or some other change might be felt. For example, you find out that a new assignment is needed and as a result changes to the project schedule and cost baseline will need to be made. In such cases, you will create change requests that would be processed through the pro forma Integrated Change Control process.

9. Make updates to documents, such as those listed in the output column of Table 6-5, that may be needed as a result of performing this process.

In this section, we have discussed how to yield the output of this process, starting from the input, by using certain tools and techniques, which will be discussed next.

Caution! Resource calendars are created as an output item of the Acquire Resources process and evolve in a progressive elaboration manner throughout the project as the process is iterated. This output is also used as an input to this process.

Tools and Techniques for Acquiring and Selecting Project Resources

In this section, we will discuss some techniques to select and acquire the project resources, starting with pre-assignments.

Pre-assignments. At this stage of the project, there will likely be some team and physical resources already assigned to the project. This can happen, for example, in the following situations:

- A team member was promised an assignment as part of a specific proposal. Acceptance of this proposal automatically affirms that staff-member assignment.
- There is only one person in the organization who has the expertise to perform a specific activity.
- Team members were already involved in the project, taking part in developing the project charter and other processes, before the development of the resource management plan.

Decision-making Techniques. These techniques are used to select suitable resources that can be efficiently and effectively used to perform the project work. For example, in the multicriteria selection method, different resource options are compared and scored based on several given criteria, and the resource with the best score is selected. In a score scheme you can weight different criteria depending upon their importance. The criteria and their relative importance partially depend on the project. The general examples include cost; timely availability; good fit with the team; right knowledge, skill, experience, and attitude; and ability to efficiently and effectively perform the assignment.

Interpersonal and Team Skills: Negotiations. While not the only one, a very important interpersonal skill that you will be using to acquire resources is negotiations. The project manager and the project management team should effectively negotiate and exert influence in a positive way to obtain the best possible team to complete the project work. The failure to acquire an effective team can result in missed deadlines, cost overruns, poor quality, and eventually a failed project. You will most likely need to negotiate with functional managers for the staff assignments for your project. In these negotiations, you have a two-prong goal—to obtain the best available person for an activity and to obtain the person for the required timeframe.

Tip While negotiating with a functional manager, sometimes it's important to understand the functional manager's perspective in light of the politics of the organization and to be able to influence the manager in that context. For example, a functional manager will weigh the benefits (for example, visibility of your project compared to that of competing projects) in determining where to assign the best performers. In this case, it is to your advantage to explain the importance of your project and the activity for which you are requesting the best performer.

You may also be negotiating with project management teams of other projects who might be competing for or sharing resources, physical or human, from the same resource pool. Negotiation skills will also be used to communicate with external organizations to hire or contract team members.

Virtual Teams. Welcome to the Information Age, triggered by the Internet. The process of working for an organization from outside its physical location was initially called *telecommuting,* and now also *e-commuting*. Today, we have the Internet, along with related and other technological advances, such as tele-, video-, and web conferencing, smartphones, websites, and web-supported e-mails and social media. This makes it possible to e-commute from virtually any place on the globe for any organization. Teams composed of e-commuters are called *virtual teams* because the team works together on the same project with little or no face-to-face interaction or meetings. It is not difficult to find people who have been or are working on virtual teams and have never seen the other team members face-to-face. I have and still am working with several such teams, and I'm sure you either have or you will in the near future. The virtual-team format expands the *team* definition to offer benefits such as the following:

- People working for the same organization but living in different locations can join the same team.
- A needed expert can join a team even if the expert does not live in the same location as the rest of the team.

- The organization has the option to accommodate employees who can only work from their home offices for certain periods of time.
- Due to the availability of asynchronous communication means, such as e-mail, online bulletin boards, and social media, it is possible to form a team of members who have different work hours or shifts.
- Virtual teams eliminate or reduce the need to travel by using means of communication that are abundantly available, such as e-mail, video conferencing, and the Internet.
- This enables organizations to perform projects that were previously impossible due to the anticipated travel expenses.

Note that because virtual team members are not at the same location and do not have regular face-to-face meetings, effective communication is that much more important for the success of the project being performed by the virtual team. Therefore, communication management is crucial to the success of virtual teams.

STUDY CHECKPOINT 6.2

Use your knowledge of the Acquire Resources process to answer the following questions:

Q1. List some EEFs that can influence the process of acquiring resources.

Q2. List some OPAs that can influence the process of acquiring resources.

Q3. How are the documents listed for update in the output column of Table 6-6 updated?

The team you are going to acquire could be a team at one location or a virtual team, and a team member might be from your organization or from outside your organization. In other words, you hire the individuals, but you need a team to complete the project successfully. Virtual or non-virtual, once initiated, a team needs to be continually developed.

Developing the Project Team

Your project team can consist of members from different departments and disciplines, regular employees and contractors, and experts from different disciplines. Some of these individuals might not have much appreciation for others' disciplines. You have the challenge to develop this diverse group into a cohesive and efficient team that will perform the project on time, within budget, and with quality. The single goal of team development is to maximize project performance. This is accomplished by introducing three elements:

1. Improve the competencies of team members.
2. Improve the interaction among team members.
3. Improve the overall team environment.

This will help you develop a cohesive and competent team to meet the project objectives effectively.

Tip Each team member should be the owner of the piece of work assigned to them, and hence be fully responsible for it. That said, teamwork and team spirit is a critical factor for the project's success. It's the responsibility of the project manager to create an environment that supports teamwork and team spirit.

Table 6-7 shows the Develop Team process, used to develop the project team, in terms of input, tools and techniques, and output. As usual, we start with the initial information provided by the input. The resource management plan guides how to develop the project team by providing useful information on team development–related matters such as the following:

- Feedback and training strategies
- Using results of performance assessments
- Disciplinary action
- Recognition and rewards systems

Table 6-7. The Develop Team Process: Input, Tools and Techniques, and Output

Input	Tools and Techniques	Output
1. Project Management Plan: • Resource management plan 2. Project documents: • Project schedule • Project team assignments • Team charter • Resource calendars • Lessons learned register 3. Enterprise environmental factors 4. Organizational project assets	1. Co-location 2. Virtual teams 3. Communication technology 4. Meetings 5. Interpersonal and team skills: • Influencing • Conflict management • Motivation • Negotiations • Team building 6. Individual assessments 7. Training 8. Recognition and rewards	1. Team performance assessment 2. Change requests 3. Project Management Plan updates: • Resource management plan 4. Updates to project documents: • Project schedule • Project team assignments • Resource calendars • Team charter • Lessons learned register 5. Enterprise environmental factors 6. Organizational project assets

Obviously, team development starts with team members and information about them and the staff assignments made during the Acquire Resources process. The *project team assignments, project schedule,* and *resource calendars* documents will reveal their names, assignments, roles, responsibilities, time they are available for trainings, and maybe much more. Team values, operating guidelines, and rules are given in the *team charter* document developed during the Plan Resource Management process. With this information on hand, you can start team development, which is an iterative process repeated throughout the project lifecycle. In the repetition of this process, you can make use of the lessons learned in team development so far, which are recorded in the lessons learned register.

You can use some standard tools and techniques, listed in Table 6-7, to develop a winning team.

Tools and Techniques for Project

A very important management technique is to establish clear expectations at the very beginning of a project. The expectations can be established by implementing a set of ground rules. Early commitment to these guidelines will increase cooperation and productivity by decreasing misunderstandings. Once the rules are clearly established, all team members are responsible for enforcing them. These ground rules are part of the team charter document.

Other techniques are discussed in the following sections.

Co-location and Virtual Team. This technique keeps all (or most) of the project team members in the same physical location to improve communication and to create a sense of community among the team members. In this age of virtual teams, however, this is increasingly not a popular technique, but when most of the team members are in the same location, this technique is a default choice. It can include a *war room*, which is a meeting room used for regular face-to-face meetings. Also, even when the project is being executed by a virtual team, the co-location technique can be used to put together some team members at crucial times of the project. Some virtual teams co-locate for a specific period during the project.

In the case of virtual team development, the role of communication technologies becomes that much more important.

Communication Technologies. There are abundant synchronized and asynchronized communication methods—online or offline—available, which can be used for team development and other project tasks. The following are some examples of the kinds of methods available:

- Smartphone, e-mails, web chat, web podcast, and seminars
- Audio and video conferences
- Shared web portals, discussion groups, and bulletin boards
- Social media site to set up groups

We will explore communication further in an upcoming chapter on communication management.

Note Synchronized communication is when all the communicating parties are present at the same time—e.g.; phone calls, meetings, and conferences—while asynchronized communication is where all the communicating parties do not have to be present at the same time—e-mail, website, and online courses. The Internet, in general, is designed to support asynchronized communication.

Interpersonal and General Management Skills. General management skills, especially interpersonal skills, are necessary to develop an effective team. You and the project management team can minimize problems and maximize cooperation by understanding the sentiments of each team member, anticipating their actions, acknowledging their concerns, and following up on their issues. To accomplish this, the following interpersonal management skills are necessary:

- **Effective Communication.** This is needed to facilitate the smooth flow of necessary information among the team members.
- **Ability to Influence.** This is generally needed to get things done. In team development, it will be helpful throughout, from collecting information, to meetings, to getting consent, to resolving conflict.
- **Leadership.** This is needed for developing a vision and strategy and for motivating people to achieve that vision. During times of possible uncertainty, such as when there are changes in upper management, you should clarify the situation and help the team stay focused on the project.
- **Motivation.** This is needed for energizing team members to achieve high levels of performance and to overcome barriers to change. Motivation is invoked by a given reason to act. For example, you can motive team members by letting them own their assignments, letting then participate in decision making, giving credit and reward, and motivating the team by explaining how they are making a difference by performing this important project. Especially during times when the team is in a low-morale mode, you should be able to lift the team morale and thereby contribute to team development.
- **Negotiation and Conflict Management.** This is needed to work with the team members to resolve their conflicts and facilitate negotiations when necessary to resolve conflicts or make task assignments. Depending on the nature of the conflict, you can take it as a team development opportunity. An effective resolution to a conflict contributes to team building.
- **Problem Solving.** This ability is needed to define, analyze, and solve problems.

Most of these skills are discussed in more detail in Chapter 2. Team management is further discussed later in this chapter.

Note Interpersonal skills are also called soft skills, as opposed to hard skills, which refer to technical skills and capabilities.

Team-building Activities. In general, team building involves activities that encourage team members to get to know each other and create a collaborative, cooperative, and supportive team and work environment. Team-building activities can range from indirect team-building activities, such as participating in constructing the WBS, to direct team-building activities, such as social gatherings where the team members can get to know each other and start feeling comfortable with each other. While planning such activities, you should keep in mind that the team members might have different interests and different levels of tolerance for games and icebreakers. Although team building is an ongoing process, it's crucial in the beginning. It should start as soon as possible. For example, the project kickoff meeting is an indirect method to start team development. This can be used as a formal way to introduce team members and other stakeholders and spell out the project goals for everyone at the same time. An ideal kickoff meeting is a combination of serious business and fun. The goal is to align the team with the project goals and to help the team members feel comfortable with each other.

In planning the kickoff meeting, you can assume that team members have the following questions in their heads that need to be answered before the end of the meeting:

- Why am I here?
- Who are you, and what are your expectations of me?
- What is this team going to do?
- How is the team going to do its work?
- How do I fit into all this?

Consider the following steps to make your kickoff meeting successful:

- **Agenda.** Putting the meeting agenda in the hands of the team members always helps the meeting run more smoothly and effectively and keeps it on track.
- **Welcome.** Take immediate charge of the meeting by introducing yourself and welcoming the participants. Quickly walk through the agenda and set the stage for the rest of the meeting.
- **Project Overview.** Define the project, its goals, and its deliverables. Introduce the project team members and briefly describe their roles. The goal is to provide a big

picture and to help individual team members figure out how they fit into it.

- **Expectations.** Many of the project team members might not already know you and your management style. You should take this opportunity to set expectations about how the team will function. For example, state that you expect all team members to attend the weekly status meetings. Remind the team to focus on the project goal, to do their part, and to look out for one another in a team spirit.
- **Guest Speakers.** Depending upon the size and visibility of the project, you might also invite relevant guest speakers, such as the project sponsor, the customer, or an executive stakeholder. Before the meeting, spend some time communicating with the guest speaker about the message to deliver.
- **Closure.** Ask for feedback and hold a question-and-answer session before closing the meeting.

Remember that the main purpose of the kickoff meeting is to bring every team member onto the same page regarding the big picture of the project. Don't get bogged down discussing every item in detail.

You should know that team development is not an instant process. Generally speaking, when you form a team it goes through five stages of development (according to the Tuckman model), as shown in Figure 6-3 and explained in the following list.

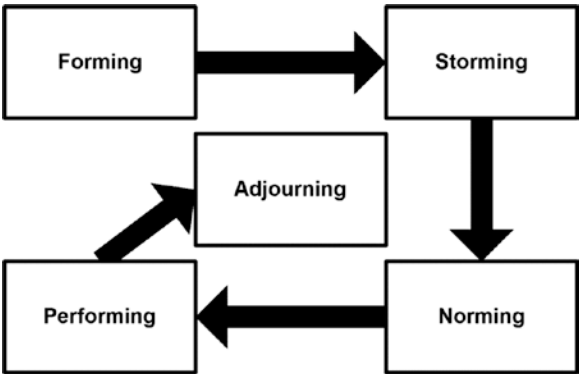


Figure 6-3. The five progressive stages of team development in the Tuckman model

- **Forming.** This is the orientation stage, with high dependence on the leader (the project manager, in this case) for guidance and direction. Individual roles and responsibilities are unclear, and there is little agreement on the team goals other than those received from the leader. Processes are often ignored, and the team members test the tolerance of the system and the leader. It's time to establish the ground rules and clarify expectations. The leader directs in this stage.
- **Storming.** This stage represents the struggle for control and power as team members work to establish themselves relative to other team members. The clarity of team goals increases, but some uncertainties persist. Compromises might be required to make progress. Coaching and training can play effective roles during this stage.
- **Norming.** This is the routine stage during which consensus and agreement about team goals generally prevails among the team members. Roles and responsibilities are clear and accepted by the team members. Major decisions are made by group agreements, and smaller decisions can be delegated to the appropriate team members. During this stage, the leader facilitates.
- **Performing.** This is the productivity stage in which the team knows what it's doing and why. The team is functioning in a cohesive mode and working toward the common goal in a more autonomous fashion. Disagreements might arise, but they are resolved within the team in a constructive way. During this stage, the leader delegates and oversees.
- **Adjourning.** This is the closure stage. When the mission for which the team was formed is accomplished (or cancelled), the team is adjourned to free the team members to move on to other things.

Being aware of these stages of team development will help you better understand the behaviors of the team members and thereby develop your team more effectively.

Training. The goal of training is to improve the competencies of the project team members, which in turn helps in meeting the project objectives. It might be aimed at individual members or at the team as a whole, depending upon the needs. The training might be scheduled, or it might be less formal—e.g.; it

might result from on-the-job observations and conversations. The following are examples of some other training methods:

- Coaching
- Mentoring
- On-the-job training of a team member by another team member
- Online training
- Instructor-led classroom training

Observation and conversation. Although not listed separately in the PMBOK for this process, observations and conversations are both means to stay in touch with the work and attitudes of the project team members. The indicators to monitor these include the following:

- Progress toward completion of assigned activities and therefore project deliverables.
- Distinguished accomplishments contributing to the project performance.
- Interpersonal issues.

Individual and Team Assessments. In order to continually develop the team, it's important to know and track the areas of strengths and weaknesses of the team and its members. You want to assess the team members individually and collectively; for example:

1. What are their preferences, and what inspires them?
2. How do they interact with other people?
3. How do they process information?

Various tools are available to accomplish this, including focus groups, interviews, ability tests, surveys, and online tests designed for this purpose.

Recognition and Rewards. Generally speaking, people feel motivated if they feel that their contributions and efforts are recognized and valued. Offering rewards is an effective method to express the recognition. The recognition and rewards strategy set up during the resource planning process can be used to develop the project team. Remember the following rules when setting up a fair reward system:

- Only desirable behavior should be rewarded.
- Any member should be able to win the reward.
- Win–lose rewards, such as team member of the month, can hurt team cohesiveness.

- It's important to consider the value of the particular award from the awardee's perspective.
- The cultural diversity of the team should be considered and respected.

Output of Team Development Process

The major output of the Develop Project Team process is the team performance assessment document. This and other outputs are explained next.

Team Performance Assessment. The effects of the team development efforts are measured by the individual and team performance assessments and recorded into the team performance assessment document. It contains information that includes the following:

- Improvement in individual skills that enables a team member to perform project activities more efficiently
- Improvement in team skills that helps the team improve overall performance and work more effectively as a group
- Increased team spirit or cohesiveness: team members interact in constructive ways and help each other meet the project objectives
- Reduced staff turnover rate

Change Requests and Document Updates. As a result of the develop team process, changes may arise. So, change requests must be generated and processed through the Integrated Change Control process, as usual. Approved changes are implemented, and corresponding documents are updated. The obvious documents that might get updates are listed in the output column of Table 6-7. Knowing the process, the reasons for their updates should be trivial to figure out. For example, based on the team development experience of which methods work better than others, changes could be made to the relevant part of the *resource management plan*, and the *lessons learned register* should be updated accordingly. Similarly, team development could cause changes to assignments and the schedule, and so on.

While you are developing the team, you also need to perform a related task, which is managing the project team.

Managing the Project Team

You manage the project team by using the Manage Team process, which is aimed at improving and optimizing the project performance by executing the following tasks:

- Resolving issues and conflicts
- Coordinating changes

- Tracking the performance of each team member and of the team as whole
- Providing feedback to team members individually and to team as a whole

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Tip Managing the project team involves activities ranging from hiring to firing and from providing feedback to optimizing the project performance, and therefore requires a wide spectrum of management skills, including communication, conflict management, negotiation, and leadership. On one hand, you should provide challenging assignments, and on the other hand you should recognize and reward high performance.

Table 6-8 presents the Manage Team process in terms of input, tools and techniques, and output.

Table 6-8. The Manage Team Process: Input, Tools and Techniques, and Output

Input	Tools and Techniques	Output
1. Project Management Plan: • Resource management plan 2. Project documents: • Project team assignments • Team charter • Issues log • Lessons learned register 3. Team performance assessments 4. Work performance reports 5. Enterprise environmental factors 6. Organizational project assets	1. Interpersonal and team skills: • Influencing • Leadership • Conflict management • Emotional intelligence • Decision making 2. Project management information systems	1. Change requests 2. Plan updates: • Resource management Plan • Schedule baseline • Cost baseline 3. Updates to project documents: • Project team assignments • Issues log • Lessons learned register 4. Enterprise environmental factors

You perform this process by getting information about the team, some means to manage it from the input items listed in Table 6-8, and then manage it using the tools and techniques also listed in that table.

Getting Information About the Team and Means for Managing It

The main input items to managing the project team come from the output of the Plan Resource Management, Acquire Resources, and Develop Team processes. You extract the needed information from them as shown next.

How to Manage the Team?

You can get general guidance on how to manage the team, including releasing the team at the end of the project, from the *resource management plan*.

Knowing the Team.

To manage the team, you want to know who composes the team, what the team is doing, and how (well) it is doing. This information can be extracted from the following documents.

Project Team Assignments. Obviously, you should know who your team members are and what they are supposed to be doing: their roles and responsibilities. Project team assignments, an output of the Acquire Resources process, contains this information.

Assessment and Performance Information. The following items will yield this information:

- **Team Performance Assessment.** This is the output of the Develop Team process discussed earlier in this chapter. Performance assessment provides important information that can be used in managing a team member and in managing the team. This assessment helps you to understand a team member and identify and address issues. Some examples are the need to resolve conflicts, the need for training, and the need to modify communication.
- **Performance Reports.** Performance reports compare the progress of the project against the baseline data, such as the schedule baseline, the cost baseline, and the quality baseline. They basically reflect how the team is doing to achieve the project objectives. The information from the performance reports helps determine future team requirements, such as the need for more members, updates to the resource management plan, and recognitions and rewards. It may also reveal the need for training or a change of assignments.

Means to Facilitate Team Management. The following input documents or the information in them serve as a means to facilitate team management:

- **Team Charter.** An output of the Plan Resource Management process, the team charter document contains information about team values, operating guidelines, and ground rules. These values and rules help and facilitate team management by guiding how to make decisions and resolve issues and conflicts. This further facilitates team management if the team took part in developing the team charter and agreed to it.
- **Issues Log and Lessons Learned Register.** The *issues log* can be used to facilitate a team-related issue resolution by logging in the issue information, including resolution target date. Issues generally involve obstacles that can stop the project team from achieving the project objectives. A written log should be maintained that contains the list of team members responsible for resolving the issues by target dates. The purpose of the issues log is to monitor issues until they are closed.

  The lessons learned register can facilitate team management in the sense that you can use it to record the ongoing lessons learned in managing the team so as to subsequently use them to improve the efficiency and effectiveness of team management.
- **Enterprise Environmental Factors and Organizational Process Assets.** The project management team can use the following EEFs and OPAs in managing the project team:
  - Enterprise environmental factors that should be available to the project management team for use in managing the team include bulletin boards, newsletters, and internal websites for information sharing.
  - The OPAs that can influence team management include the organization's policies, procedures, and system for rewarding team members. Certificates of appreciation, recognition dinners, and bonus structures are some examples.

To manage the team effectively, you should be aware of the tools and techniques that can be used for that.

Tools and Techniques for Managing the Project Team

Interpersonal skills used to manage the team include leadership skills, one of three skill types in the project manager's *talent triangle* (covered in Chapter 2); influencing (also covered in Chapter 2 in much detail); decision making (covered a few times in different situations so far); conflict management; and emotional intelligence.

Influencing. *Influencing* means getting individuals or groups to do what you want them to do without necessarily having formal authority to mandate an outcome from them. It is quite important, as under many formal and informal organizational structures, project managers have no or very little practical authority. So, in that case, to get work done, your only option is to use influencing skills, such as collecting all information about the given issue or situation; understanding all different perspectives on it; listening actively and effectively; clearly explaining your points and perspective while demonstrating consideration and understanding for the other perspective; having the ability to pursue resolution; and reaching an agreement without damaging the ongoing working relationship.

Decision Making. In managing the team, you will be dealing with the team and the organization, making decisions based on the options or choices available. However, first you need to create the choices by using your skills of negotiation and influence on the organization and the team, as well as by stimulating a creative environment within your team. For that, you should always do your homework. Collect all relevant information, including the relevant environmental factors about the issue at hand, and analyze this information. In your analysis, don't forget to include the risk factors. After creating choices and analyzing, you can make decisions while following the rules in the team charter.

Emotional Intelligence. Emotional Intelligence, in general, is the ability to sense and manage one's own and other people's emotions, where *manage* means understand the emotions, their impact, and controlling the impulse to adapt in order to change the situation. You and your team can use emotional intelligence to reduce the tension among team members so as to create an environment of collaboration by anticipating and understanding each others' reactions and emotions. You can also use relationship management, a part of emotional intelligence that guides how to influence, inspire, and develop the team while resolving conflict.

Conflict Management. The purpose of conflict management is to nourish the positive working relationships among team members that result in increased productivity. The common sources for conflicts include the following:

- Scarce resources resulting in unsatisfied needs
- Scheduling priorities

- Personal work styles
- Perceptions, values, feelings, and emotions
- Power struggles

You can reduce the number of conflicts by setting ground rules, clearly defining roles and goals, and implementing solid project management practices. In this, the *team charter* is important.

Tip Differences of opinion should not be considered sources of conflict. If managed properly, differences can be very healthy and can lead to better solutions, thereby increasing productivity if managed appropriately.

Initially, the project team members who are parties to a conflict should be given the opportunity to resolve it themselves. If the team members fail to resolve the conflict and it becomes a negative factor for the project, you, the project manager, should facilitate the conflict resolution, usually in private and using a direct and collaborative approach. If the conflict continues, you might have no option other than to use formal procedures, such as disciplinary action.

Different project managers use different styles or methods in different situations. The choice of the conflict-resolution style or technique may be influenced by the following factors:

- Does the conflict need to be resolved for the long term, or is a short-term resolution fine?
- The intensity of the conflict and the relative importance of resolution in context of the project
- Urgency of resolving the conflict
- Positions taken by the parties involved in the conflict

The first step in conflict management is analyzing the nature and type of the conflict, which might involve asking questions. You can meet with (interview) the parties involved in the conflict. The next step is to determine the management strategy. Different management strategies are summarized here:

- **Avoidance.** In this strategy, at least one party to the conflict ignores (or withdraws) from the conflict and decides not to deal with the problem. This strategy can be used by the project manager as a cooling-off period, to collect more information, or when the issue is not critical. However, if the issue is critical, this is the worst resolution

strategy and can give rise to lose–lose situations if both parties withdraw or yield–lose situations if one party withdraws. This strategy is also called *withdrawal strategy*.

- **Direct.** In this approach, also called *force*, one party uses any available means to get its way, often at the expense of the other party. This is a win–lose situation. It can be justified in some situations, such as when the basic rights of a party in conflict are at stake or when you want to set a precedent. However, if used unfairly from a power position (such as if it is a management style), it can be destructive for team development. This strategy can cause the conflict to escalate, and the losing party might attempt to retaliate. When used by a party in power, competition is also called *forcing*.
- **Compromising.** In this strategy, also called *reconcile*, both parties gain something and give up something. This is a lose-win–lose-win strategy. You can use this strategy to achieve temporary solutions and to avoid a damaging power struggle when there is time pressure. The downside of this approach is that both parties can look at the solution as a lose–lose situation and can be distracted from the merits of the issues involved. In this way, this short-term solution can hurt the long-term objectives of the project.
- **Accommodation.** This strategy, also called *smoothing*, is the opposite of the competition strategy. One party attempts to meet the other party's needs at the expense of their own. This might be a justifiable strategy when the concerns of the accommodating party are less significant than the concerns of the other party in the context of the project. Sometimes it's used as a goodwill gesture. However, it is a lose–win approach (the accommodating party loses and the accommodated party wins), and the accommodating party runs the risk of losing credibility and influence in the future. However, this strategy, when applied carefully, and if both parties become accommodating, meeting in the areas of agreement, can turn into a win–win situation. This is why this technique is also called *smoothing*.
- **Collaboration.** This strategy, also called *problem solving*, is based on reaching consensus among the parties in the conflict. Both parties work together to explore several solutions and agree on the one that satisfies the needs and concerns of both parties. This is a win–win strategy and is

generally considered the best of all the strategies because it helps build commitment and promotes goodwill between the parties involved. A form of collaboration is called *confronting*. You confront the problem causing the conflict head-on and then solve that problem through an open dialogue and by examining several alternatives. This is *problem solving*.

Tip You should always look for how the different processes overlap and interact with each other. For example, conflict management is a technique for managing the team. However, the purpose of conflict management is to nourish the positive working relationships among the team members that result in increased productivity, so resolving a conflict can also be looked upon as a team development activity.

As mentioned earlier, leadership skills are covered in Chapter 2, and you should already be familiar with project management information systems by now and here you can use it for managing the team, as it contains the schedule, calendar, and other management tools.

STUDY CHECKPOINT 6.3

Each comment in the first column of the following table points to a conflict-resolution strategy. Match each comment with the corresponding strategy in the second column.

Comment	Conflict-Resolution Technique
A. Let's have a face-to-face meeting and hear out both parties.	1. Avoidance/withdrawal
B. Both of you have to meet halfway; you can't get everything all the time.	2. Competition/forcing
C. I'm the one who is running the show here, and I have made the decision.	3. Compromising/smoothing
D. OK, I see your point now. I was thinking more at personal level, but your view is more compatible with the project's objectives. I guess for that reason I can live with your approach.	4. Accommodation
E. You guys are not even listening to my argument. I feel I'm wasting my time. So, I'm not going to discuss it with you any longer.	5. Collaboration
F. Let's sit down, talk it out, and design the best solution that is good for all parties.	6. Confronting/problem solving

Caution! Not only can you earn quite a few points on the PMP exam, but you can also be a very effective project manager if you realize this: confront the problem or the issue head-on, but do your homework (investigate, research, or analyze) before taking action.

While you are managing the team using these techniques, you might recommend some actions as an output of the Manage Team process.

Output of Managing the Project Team

The output from managing the project team includes change requests—e.g.; from recommended corrective and preventive actions—and updates to organizational process assets and the project management plan.

Change Requests. You or the Manage Team process might generate recommendations for corrective and preventive actions, as well as other changes, as discussed here:

- **Recommended Corrective Actions.** A corrective action is a direction for executing the project work to bring the future performance in line with what is expected in the project management plan. The corrective actions recommended during project team management might include the following:
  - Staffing changes, such as changing assignments of team members, replacing team members (for example, the ones who leave), and outsourcing some work
  - Training for the team or for individual team members
  - Recognition and rewards based on the reward system
  - Disciplinary actions
- **Recommended Preventive Actions.** A preventive action is a direction to perform an activity to stop or reduce the probability of an anticipated event occurrence generally associated with a project risk. Preventive action can also be taken to reduce the anticipated impact of an event in case it happens. The preventive actions recommended during project team management might include the following:

- Cross-training so that in the absence of a team member another team member can take over the assignment
- Role clarifications to ensure that all the responsibilities associated with the role are performed
- Planning for overtime in anticipation of extra work that might be needed to meet project deadlines

Other Change Requests and Updates. The team management activities can generate some change requests for the project management plan. For example, staffing changes can generate requests for extending the schedule, increasing the budget, or reducing the scope. The change requests should be processed through the Integrated Change Control process. Approved and implemented changes will trigger changes to the resource management plan, schedule baseline, and cost baseline. Of course, due to arising issues, change in assignments, and lessons learned in the course of team management, there will be a need to update the issues log, project team assignments, and lessons learned register.

Updates to Organizational Process Assets. Several kinds of organizational process assets can be updated as a result of project team management. Here are some examples:

- **Input to Organizational Performance Appraisals.** The project team member's project work performance and interaction with other project team member is a significant way to offer input to the organizational performance appraisal for that team member.
- Templates and organization's standard processes
- **Lessons-learned Database.** The lessons learned database should be updated with the lessons learned during team management, which can come from different areas that include the following:
    - Issues and solutions in the issues log
    - Special skills and competencies discovered during the project work for the team members
    - Successful and unsuccessful ground rules, conflict management techniques, and recognition events

Tip Managing the project team is a complex task when the team members are accountable to both the project manager and the functional managers. Effectively managing this dual relationship is critical to the success of the project and is therefore generally the responsibility of the project manager.

Interpersonal skills and an understanding of organizational theories is very important in managing human resources. Motivation is the key factor.

Motivating Your Team

Because you have come so far in studying this book, I must say you are motivated to take the CAPM exam, learn about project management, or both. So, what is motivation? Motivation is an internal drive to meet a set of objectives. Internal drive is a state of unrest inside of you. This is how it goes. A need is a deficiency, an absence of something, a hole. Out of need arises the desire to fulfill the need. This desire or want represents dissatisfaction, which creates a state of unrest. This unrest is the drive. When drive is directed at a call for action to meet those objectives that will satisfy the need, it becomes motivation. In a nutshell, the need acts as a catalyst, like an enzyme in a biochemical reaction, that sets you on a journey toward meeting a set of objectives that will satisfy the need.

If you want to get optimal results from your computers, you network them appropriately and execute appropriate software programs on appropriate drives in the network. If you want to achieve optimal results from your team, you create the appropriate drives in the team members that will execute actions to meet project objectives; in other words, you motivate them.

This is how important motivation is: motivation to do some task plus the ability to do that task is equal to performance. So, a lack of motivation means poor performance. In a project, motivation begins with you, the project manager. You must be motivated for the project and to motivate the project team members. It's always a good idea to have some formal knowledge of something that you are going to go through. So, here are some theories of motivation.

Maslow's Hierarchy of Needs Theory. According to this theory, people have layers of needs, as illustrated in Figure 6-4, and until the lower-layer needs are satisfied, they will not move to satisfy the upper-layer needs. For example, if you are unemployed and broke and as a result your very survival is in danger, you don't care about buying health insurance, life insurance, or dating.

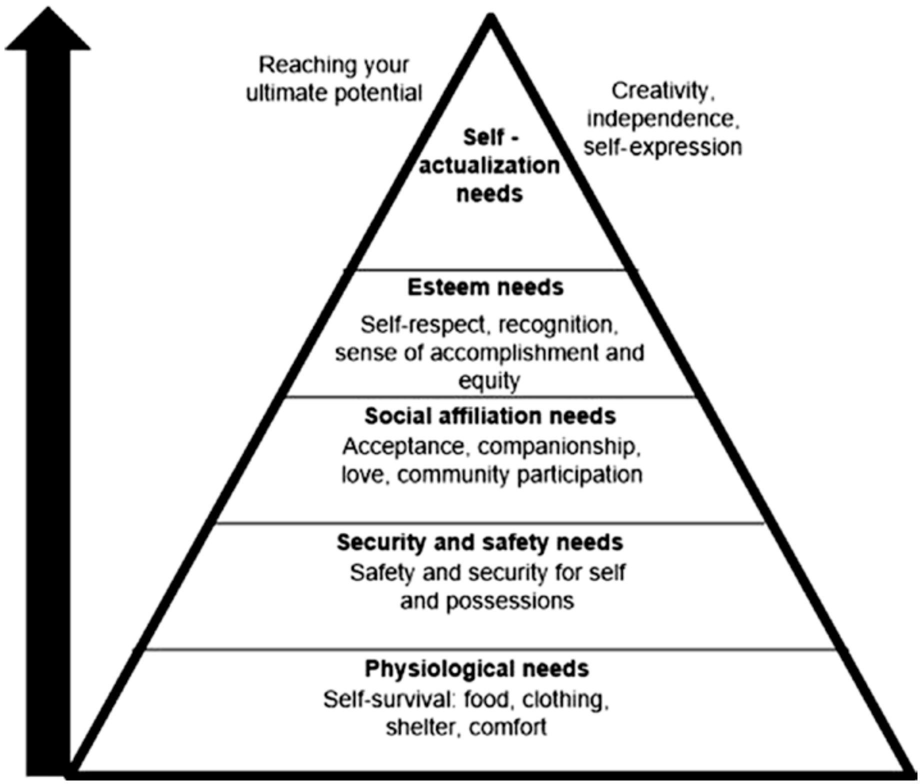

Figure 6-4. Illustration of Maslow's theory of hierarchy of needs (Based on Motivation and Personality, Abraham Maslow, 1970, Harper and Row)

Herzberg's Motivation-Hygiene Theory. This theory classifies the factors needed to motivate people into two categories: hygiene factors and motivating factors. Hygiene factors are necessary for motivation but not sufficient; they do not bring satisfaction, but they prevent dissatisfaction. Some examples are compensation; company policies; level of supervision or ownership of the assigned work; relationship with superiors, subordinates, and peers; and working conditions. Motivating factors are the factors that bring (or increase) job satisfaction. Some examples are challenging work assignment, opportunity for career advancement and accomplishments, opportunity for growth, sense of responsibility, and recognition.

Caution! Hygiene factors are related to the work environment, whereas motivating factors (also called motivators) are related to the work itself.

McClelland's Achievement Motivation Theory. According to this theory, the following three needs motivate people:

- **Achievement.** This is the need to perform well, achieve success, and get recognized for it. The key idea here is the drive to excel.
- **Affiliation.** This is the need or desire for good relationships at work. You want to feel connected at work.
- **Power.** This is the desire to move things, to influence people or events. The key term here is *world dominance* or *making a difference*.

McGregor's X-Y Theory. According to McGregor, there are the following two types of managers:

- **Theory X Managers.** These managers believe that most people (and hence workers) are self-centered and are only motivated by their physiological and safety needs, and are indifferent to the needs of the organization they work for. They (workers) lack ambition and have very little creativity and problem-solving capacity. As a result, they dislike their work and will try to avoid it. They will also avoid taking responsibility and initiative. There is one word to describe theory X managers: *distrust*. They distrust their employees. These managers, therefore, tend to be authoritarian.
- **Theory Y Managers.** As opposed to theory X managers, theory Y managers trust their employees. They believe that most of the people are high performers in a proper work environment. This is because most of the people are creative and committed to meeting the needs of the organization they work for. They also believe that most people like to take responsibility and initiative and are self-disciplined. Finally, they also believe that most people are motivated by all levels of needs in Maslow's hierarchy of needs. These managers tend to provide more freedom and opportunity for career growth.

Expectancy Theory. According to this theory, people are motivated only if they expect a desired outcome or reward. The key idea here is: what is in it for me? The desired outcome here has two components: objectives will be met with this effort, and the performers will be rewarded.

STUDY CHECKPOINT 6.4

Each comment in the first column of the following table points to a management theory in the second column. Match each comment with the corresponding theory in the second column.

Scenario	Motivation Theory
A. The management is real nice to the employees and there are lots of perks. But I'm more concerned about my career path once I join this company.	1. Maslow's Hierarchy of Needs Theory
B. Engineering manager Bob has a habit that employees don't like. Every time he passes by a cubicle of an employee, he peeps at the computer screen over the shoulders of the employee to see what the employee is really doing on the computer.	2. Herzberg's Motivation-Hygiene Theory
C. Rachel Janowicz quit her project management job with the Gugu Gaga company immediately after winning the California super lotto. She said, "Well, my money problem is solved. Now I will do what I always wanted to do."	3. McClelland's Achievement Motivation Theory
D. I'm not going to attend this seminar. Basically, I'll be listening to their pitches all day long. What are the odds that I'll win the door prize?	4. McGregor's X-Y Theory
E. Kushal did not really like the assignment. But he did it anyway because he did not want to let his manager down.	5. Expectancy Theory

Caution! The Expectancy Theory, applied carelessly, can backfire. For example, if the expected reward is unachievable or not worth the effort, people will get de-motivated.

Controlling Project Resources

The project's physical resources are monitored and controlled using the Control Resources process. By monitoring the planned versus actually allocated resources, this process makes sure that the planned resources are made available to the project at the planned time. It tracks not only the shortage of resources, but also their surplus, and makes sure used resources are released in a timely manner. Table 6-9 presents the control resources process in terms of its input, tools and techniques, and output.

Table 6-9. The Control Resources Process: Input, Tools and Techniques, and Output

Input	Tools and Techniques	Output
1. Project Management Plan: • Resource management plan 2. Project documents: • Project team assignments • Project schedule • Physical resource assignments • Resource breakdown structure • Resource requirements • Issues log • Risk register • Lessons learned register 3. Agreements 4. Work performance data 5. Organizational project assets	1. Interpersonal and team skills: • Influencing • Negotiation • Problem solving 2. Data analysis: • Cost-benefit analysis • Performance reviews • Trend analysis • Alternative analysis 3. Project management information systems	1. Work performance information 2. Change requests 3. Plan updates: • Resource management plan • Schedule baseline • Cost baseline 4. Updates to project documents: • Physical resource assignments • Resource breakdown structure • Assumptions log • Risk register • Issues log • Lessons learned register 5. Enterprise environmental factors

In short, the central task of controlling physical resources is to keep the triangle of planned, allocated, and used resources synchronized, as illustrated in Figure 6-5. It means that all resources as planned are allotted, and all allotted resources are being used. To make that happen, you will be monitoring the planned, allocated, and being used resources; analyzing this resourced data and creating change requests; and making sure that those change requests are processed. In the process of doing all this, you will obviously be communicating with relevant resource stakeholders.

In the following, we discuss this process in the form of steps:

1. **Get How-to Information.** First, find out from the *resource management plan* the general information on how to use, control, and release the physical resources.

2. **Get General Resource Information.** From *resource requirements* and *RBS*, find the reference for detailed resource information. This information will be useful in case a resource needs to be replaced or more of it needs to be acquired.

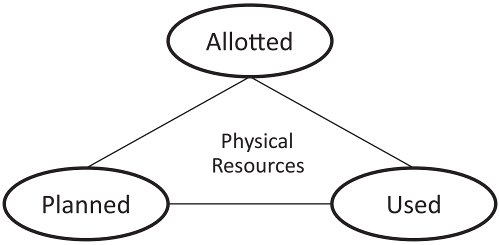

Figure 6-5. Control Resources process: synchronize planned, allocated, and used resources

3. **Get Process Facilitators.** While performing this process, be aware of the risks attached to the resources, as recorded in the *risk register*. Also, continually use the *lessons learned register* to record the lessons learned during this process for subsequent use. Moreover, *agreements* made are recorded into documents when issues arise with the resources in use, or when the new resources are acquired during the project execution. Here, we are talking about the resources external to the organization.

4. **Get Information About Scheduled and Assigned Physical Resources.** The *project schedule* reveals information about needed resources: which resource and when and where it's needed. These are planned resources. *Physical resource assignments* contain information about the resources assigned to the project: resource type, quantity, assignment location, and whether the resource is internal or external to the organization. These are allocated resources.

5. **Get the Used Resource Information.** *Work performance data* provide information about the actually used resources, such as the resource type and quantity used.

6. **Synchronize Planned, Allotted, and In-use Resources.** In steps 4 and 5, you got information about planned—i.e., scheduled, allotted or assigned, and used resources. Having this information, you do the following:

    a. **Conduct Performance Reviews.** Compare and analyze the actual resource usage from *work performance data* with planned and assigned/allotted resources to prepare *work performance information*, an output of this process. This would expose any asynchronization or gaps between planned, allotted, and used resources. You then proceed to synchronize the planned, allotted, and used resources triangle, as shown in the next steps.

b. **Predict the Resource Usage.** Perform a *trend analysis* on the *work performance data* collected over time to predict the resource usage in the future. Knowing the predicted resource usage, you want to synchronize it with the planned and allotted resources, as shown next.

c. **Explore Different Solutions.** You deal with the problem of resource shortages and surpluses by adjusting cost/budget, scope, schedule, or a mixture of these three factors. You can perform a *cost-benefit analysis*, covered in the chapter on cost management, to explore the option of acquiring additional resources in the case of a shortage. Also, you can consider the other options to synchronize predicted resource usage with the planned and allotted resources, such as adjusting schedule or scope.

d. **Pick the Best Solution.** You the pick the best options by performing *alternative data analysis,* and then generate the *change requests* accordingly, another output of the Control Resources process.

e. Use your *negotiation* and *influencing* skills to get the best solution approved.

f. Based on approved and implemented changes or for other reasons in this process, update the documents that need to be updated, listed in the output column of Table 6-9.

While controlling resources, you can also use the *problem-solving* technique, which is listed in PMBOK as a technique for this process, but it is a very general approach that can be used in all disciplines of knowledge. This approach is applied to solve a problem by taking the following steps:

1. Identify and define the problem clearly.
2. Break the problem into smaller, easily solvable pieces.
3. Investigate the problem and collect data.
4. Analyze the data to discover several possible solutions.
5. Choose the best or most suitable solution.
6. Test the chosen solution to make sure that it fixes the problem.

STUDY CHECKPOINT 6.5

Using your knowledge of organizational project assets and the Control Resources process, answer the following questions:

Q1. Make a list of OPAs that would influence this process.

Q2. How should the assumptions log and risk register be updated as a result of the Control Resources process?

The three most important takeaways from this chapter are as follows:

- To lay the foundations of your project's success, you must negotiate to acquire 1) the individuals with the right skills and capability of performing the project work effectively and efficiently; and 2) the best options of physical resources.
- It is critical for the project's success to develop and manage the group of individuals to be a high-performing team.
- To optimize results, keep planned, allotted, and used physical resources in sync with each other.

Summary

To execute the project, you need to put together a project team that will perform the project work, and you and the team will need physical resources do the project work. To accomplish these tasks, you use the processes of project resource management. First, you develop the resource management plan that contains the roles needed to perform the project, the responsibilities assigned to the roles, and a guide on how to perform other processes in resource management. To start with, you estimate the team and physical resources for each project activity defined in the previous chapter by using the Estimate Activity Resources process. With this resources information in hand, perform the Acquire Resources process to obtain individuals and physical resources. The goal is to negotiate to obtain the individuals with the right skills and capability of performing the project work effectively and efficiently and to obtain the best options for physical resources.

Having obtained the individuals, you use the Develop Team process and Manage Team process to turn this group into a high-performance team by 1) identifying the areas of improvement and facilitating that improvement—e.g.; competencies, interaction with other team members, and overall team environment; and 2) tracking performance, providing feedback, resolving

conflicts, and managing changes. Finally, use the Control Resources process to optimize the results by keeping the planned, allotted, and used physical resources in sync with each other.

Road Ahead. In this part of the book, we explored how to develop the project scope baseline and project schedule baseline. There is another baseline closely related to scope and schedule baselines—the cost baseline, which we will visit in the first chapter of the next part of the book. In this chapter, besides realizing the close connection between resources and costs, we can also note the importance of communication in obtaining the best project resources and developing and managing the individuals to be a high-performance team. So, one chapter in the next part is devoted to project communication management. In the context of projects, we communicate with the project stakeholders. We explore project stakeholder management in one of the other chapters in the next part of the book.

Exam's Eye View

Comprehend

- The human or team resource planning is used to determine the roles that will perform the schedule activities and to develop the team resource management plan to fill the roles with team members.
- The goal of the Acquire Project Team process is to fill the roles defined in the staffing management plan with real individuals who will perform those roles to execute the project.
- Regardless of how much control you have over team assignments, always try to obtain the best person for the job by such means as negotiation, for which you must do your homework, which includes finding out the availability and competencies of the candidate team members.
- The project team assignments made through the Acquire Project Resources process are the input to the Develop Team process, which uses techniques such as training, recognition and rewards, and other team-building activities to develop a high-performance team from team members, who were just a group of people to start with.
- You must manage the team in order to optimize its performance.
- The Control Resources process is all about keeping the planned, allotted, and used physical resources in sync with each other.

Look Out

- Planning resource management includes both human and physical resources.
- Information about responsibility for assignments among human resources will be scattered across different parts of the project management plan, including the quality, risk, and communication plans.
- Planning resource management does not assign the resources; assignments happen in the Acquire Resources process.
- Resource calendars are an output item as well as an input item for the Acquire Resources process.
- Project calendars are both an input and an output of the Acquire Resources process.
- The project manager should effectively negotiate and exert influence in a positive way to obtain the best possible team to complete the project work.
- The failure to acquire an effective team can result in missed deadlines, cost overruns, poor quality, and eventually a failed project.
- The Control Resources process is about physical resources only.

Memorize

- Responsibility assignment matrix, *RAM,* is a matrix used to specify the relationships between schedule activities, the roles to perform those activities, and the team members assigned to the roles.
- The project management plan is an input item to all the resource management processes except the one that generated it. This is because the project management plan contains the resource management plan.
- Resource breakdown structure is an output of the Estimate Activity Resources plan.
- Team development goes through five progressive stages: forming, storming, norming, performing, and adjourning.
- The strategies used to resolve conflicts include avoid/withdraw, force/direct, compromise/reconcile, accommodate/smooth, and collaborate/problem solve. Collaboration is the best strategy because it offers a win–win resolution.

Review Questions

1. Management has asked you to produce a chart that depicts the resource needs for all the activities in the project. Which of the following charts is management referring to?

   A. The project organizational chart

   B. WBS

   C. The roles and responsibilities chart

   D. The responsibility assignment matrix

2. Which of the following is not an output of the Plan Resource Management process?

   A. Project organizational chart

   B. Roles and responsibilities

   C. Resource requirement

   D. Team charter

3. Which of the following is a true statement about the team charter?

   A. It is an output of the develop team process.

   B. It is an output of the team management process.

   C. It is an output of the resource planning process.

   D. It is an input of the resource planning process.

4. Which of the following is generally the best conflict-resolution technique to resolve conflict in your team in most situations?

   A. Avoidance

   B. Compromise

   C. Accommodation

   D. Collaboration

5. Karl, one of your team members, is arguing with you over how to perform a specific task. At the end of a long discussion, you say, "Karl, I know you feel different about it, but please do me a favor and do it this way for my peace of mind." Which conflict-resolution technique are you using?

   A. Avoidance

   B. Compromise

   C. Accommodation

   D. Forcing

6. Which of the following is not a situation well suited for team-development efforts?
   A. The kickoff meeting
   B. A conflict between two groups within the team
   C. Low team morale
   D. Changes in the budget

7. You are in the beginning of executing your project, and you need to make assignments to individuals who will do the project work. Which process should you perform?
   A. Develop Resource Management Plan
   B. Develop Project Team
   C. Acquire Project Team
   D. Make Staff Assignments

8. Virtual teams are a tool and technique used in which of the following processes?
   A. Develop Resource Management Plan
   B. Develop Project Team
   C. Acquire Project Team
   D. Manage Project Team

9. You heard in the hallway that the project manager of The Da Vinci Code project, named Pappu Gloria, has very poor soft skills. If this is true, Pappu Gloria needs to improve his:
   A. Software skills
   B. Interpersonal skills
   C. Ways of handling equipment
   D. Capability to use scheduling software

10. Which of the following is not the standard tool or technique you need to acquire a project team?
    A. Survey technique
    B. Negotiations
    C. Virtual teams
    D. Pre-assignments

11. Pam Cruise, the engineering manager, receives daily progress reports from all the engineers she manages. She also visits the cubicles of the engineers several times a day to ensure that they are working and not just browsing the Web. Most of the engineers agree that she is a micromanager. What kind of management theory is she applying?
    A. Theory alpha
    B. Theory X
    C. Theory Y
    D. McClelland's Achievement Motivation Theory

12. Gary Meltzer, the engineering manager, receives weekly progress reports from all the engineers he manages. He encourages them to take ownership of their assignments. Most of the engineers agree that he trusts his engineers. What kind of management theory is he applying?
    A. Theory alpha
    B. Theory X
    C. Theory Y
    D. McClelland's Achievement Motivation Theory

13. Susan Travis, the project manager, receives weekly progress reports from all the engineers she manages. She rewards the achievements of her employees and always gives credit to her employees for their accomplishments. She is always willing to mentor her team members and to put them on a career path. She also helps the good performers to get the assignments and projects of their choice. What kind of management theory is she applying?

    A. Theory alpha

    B. Theory X

    C. Theory Y

    D. McClelland's Achievement Motivation Theory

14. Your project sponsor has asked you to ensure that allotted resources are used, unused resources are immediately released, and no unplanned resource is allotted. To ensure that, which process would you run?

    A. Plan resource management

    B. Control resources

    C. Manage resources

    D. Acquire resources

PART

III

Cost, Stakeholders, and Communication

You can largely define your project in terms of baselines, as well as measure its progress or performance by comparing the project result with the baselines. The deviations from the baselines measure how much the project is off the track. We have already covered the scope baseline and schedule baseline. We start this part of the book by covering the cost baseline in a chapter on project cost management.

Throughout this book, we have been referring to communication, a thread that runs through every aspect of a project. Whom do you communicate with? The answer is project stakeholders, without whom there would be no project. So, following cost management, we will cover these two intrinsically connected topics in two separate chapters on stakeholder management and communication management.

CHAPTER

7

Project Cost Management

The objectives covered in this chapter make up 8 percent of the CAPM exam, equivalent to about 11 questions. Study the whole chapter in detail.

It's enough to just remember the name of the input, tools and techniques, and outputs. You should know what is in a given input item that the given process uses and how it helps in generating the output, and what a given tool or technique does in a given process.

You should understand very well the concepts and methods of cost estimates, earned value management (EVM), earned value analysis, variance analysis, reserve analysis, to-complete performance index, and so on.

While studying this knowledge area and its processes, pay attention to how the tasks can be tailored to your needs, and recognize agile environment in action; continual assessment generates change requests, which lead to changing plans—i.e., adapting.

P. Sanghera, *CAPM® in Depth*, https://doi.org/10.1007/978-1-4842-3664-2_7

CAPM Exam Objectives

Project Cost Management:

1. Understand the four project management processes in the project cost management knowledge area.
2. dentify the input, tools and techniques, and outputs defined in the four processes in project cost management.
3. Identify key concepts in project cost management, including tailoring and special considerations for agile/adaptive environments.
4. Understand and apply basic forecasting and earned value methods for project cost management.

You need resources to execute the project schedule. For example, you need the team members—the human resources—to perform the project activities, such as a computer programmer to design and develop the program, and physical resources, such as computers. These resources are going to cost, and costs need to be managed; i.e., planned, estimated, budgeted, and controlled. Once the budget for the project has been determined, the costs need to be controlled, which includes measuring the project cost performance. Cost is intimately connected to schedule and scope. The intrinsic relationship between scope, schedule, and cost is called *triple constraint*.

So, the core question in this chapter is: how do you manage the project cost? This issue breaks down into three avenues that we will explore: estimating cost, determining budget, and controlling cost.

Project Cost Management: Big Picture

Project cost management consists of developing a cost management plan, estimating costs, determining a budget, and controlling costs. First of all, we need to distinguish between *cost* and *budget*. *Cost* is the value of the inputs that have been (or will be) used up to perform a task or to produce a project outcome: product, service, or result. This value is usually measured in units of money. For example, you paid two programmers $1,000 each for developing a software program, and you paid $100 to a tester to test the program. So, the cost for the task of developing and testing the software program is $2,100. You can add the costs of components of a system, and the sum will represent the cost of the system, but it's still a cost, and not a budget. *Budget* is an aggregated cost with a timeline. You aggregate the costs of all the resources needed to perform the project and put a timeline on it: the availability of funds over time. That is called a budget.

As illustrated in Figure 7-1, cost management contains the Plan Cost Management process to generate a cost management plan according to which all the three other processes are performed. The Estimate Costs process generates the output items cost estimate and basis of estimates, which are used by the Determine Budget process to generate a cost baseline and project funding requirements, which are used in the Control Costs process.

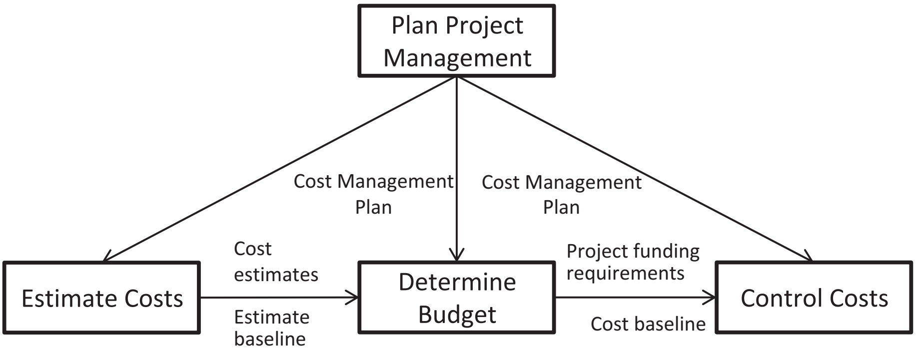

Figure 7-1. Big picture of cost management

Table 7-1 lists the processes of time management along with their process groups and major outputs.

Table 7-1. Processes of Cost Management Mapped to the Process Groups

Cost Management Process	Process Group	Major Output	Perform
Plan Cost Management	Planning	Cost management plan	Once or at predefined points in the project
Estimate Costs	Planning	Activity cost estimates Basis of estimates	Periodically throughout the project
Determine Budget	Planning	Cost baseline Project funding requirement	Once or at predefined points in the project
Control Costs	Monitoring and Controlling	Work performance information Budget forecasts	Throughout the project

Cost management starts with developing the cost management plan.

Developing Cost Management Plan

The cost management plan, developed by the Plan Cost Management process, is a guide on how to manage project costs, including estimating costs, determining budget, and monitoring and controlling costs. Table 7-2 presents the Plan Cost Management process in terms of input, tools and techniques, and output.

Caution! Cost is planned very early in the project; that is when the probability of influencing the project cost is at a maximum.

We extract raw data from input items, listed in Table 7-2, and convert it into a cost management plan by using techniques, also listed in the same table.

Table 7-2. The Plan Cost Management Process: Input, Tools and Techniques, and Output

Input	Tools and Techniques	Output
1. Project charter	1. Data analysis	1. Cost management plan
2. Project Management Plan:	2. Expert judgment	
• Schedule management plan	3. Meetings	
• Risk management plan		
3. Enterprise environmental factors		
4. Organizational project assets		

Performing the Plan Cost Management Process

Here, we describe in steps what to do to perform the process of developing the cost management plan:

1. From the *project charter*, extract information about 1) preapproved financial resources from which you can develop the detailed cost; and 2) project requirements that will influence the cost management.
2. From the *schedule management plan* and *risk plan*, get information about which processes and controls may influence cost management, such as cost estimates.

3. From *enterprise environmental factors*, get information about the factors that can influence the development of the cost management plan, such as organizational structure and culture; market conditions in terms of product availability globally and in different regions; productivity differences of different regions, which will affect the cost of project work; any relevant cost-related published data; currency exchange rates; and the project management information system to get information about different ways of managing costs.
4. From the *organizational project assets*, get information about the factors that can influence the development of the cost management plan, such as organizational policies and procedures regarding cost estimates and budgeting and financial control—e.g.; account code, time reporting, standard contract provisions, etc., and historical information from lessons learned from past projects.
5. Use *data analysis* techniques such as alternative analysis to choose one option out of many available; e.g.; to choose which funding option would be better or best: loan, self-funding, or funding with equity; or whether to make, buy, or rent a project-related item.
6. Use *expert judgment* where needed on cost management–related topics, such as cost estimate, cost control, and budgeting.
7. Put all the information collected from steps 1 through 6 together into the cost management plan document. To facilitate this, you can hold meetings with relevant stakeholders, such as the sponsor, needed team members, and anybody who has project cost–related responsibilities.

What are some specific items in the cost management plan?

Cost Management Plan

The cost management plan presents a guide to how to manage costs, including estimating, budgeting, and controlling costs. The following are examples of which items typically can be found in this plan.

Choice of Processes. Whether, for this project, cost estimation and budgeting will be performed as one process or two separate processes.

Cost Measurements: Units, Precision, Accuracy. The plan has answers for simple questions about measurements of cost and other relevant quantities; for example:

1. What are unit systems of measurement? For example, U.S. dollar, pound, Euro, or Indian rupees for money; miles or kilometers for distance; and pounds or kilograms for mass, commonly called weight.
2. What is the precision level? This refers to the rounding-off error; e.g.; rounding off to nearest whole number corresponds to an error of ±0.5. For example, $19.40 would round off to $19.00, and $19.60 to $20.00.
3. What is the accuracy level? This refers to approximation errors; e.g.; if the cost is estimated to be $100 with an accuracy of ±20%, it means that cost could be any amount from $80 to $120.

WBS Usage. Recall Chapter 4 on scope management, where we covered the work breakdown structure (WBS), which contains the component for project cost accounting called *control account*. The cost management plan may suggest using that WBS account consistently for cost estimating, budgeting, and cost controlling. The control account points may be defined inside the WBS.

How to Measure Performance. The cost management plan may define rules for cost performance measurement—for example, how to set up control account points within WBS—and include details of how to implement the earned value management (EVM) technique, how to employ estimate at completion (EAC), what cost-tracking methods to use, and so on.

Other Items. The cost management plan may specify and describe 1) the format and frequency of different cost reports; 2) the maximum cost performance deviation from the baseline allowed before a red alarm goes off to trigger an action; 3) recommended funding options; 4) procedures for documenting cost and accounting for currency fluctuations; and more.

With the project cost management plan in hand, you are ready to start working on estimating the project costs.

Estimating Project Costs

Estimating project costs means developing an estimate for the monetary resources needed to complete the project work—that is, activities. That includes both kinds of resources: team and physical. These estimates are

based on the information available at a given time. The estimates in the beginning are less accurate; for example, their accuracy may be only as good as ±50%. For example, if you say the cost will be $100,000, it could be anywhere between $50,000 and $150,000. As the project moves along and more information becomes available, the cost estimates can be improved to get better estimates.

The standard process used to estimate costs is called the Estimate Costs process and is presented in Table 7-3 in terms of input, tools and techniques, and output. Performing the process is described next.

Table 7-3. The Estimate Costs Process: Input, Tools and Techniques, and Output

Input	Tools and Techniques	Output
1. Project Management Plan: • Cost management plan • Quality management plan • Scope baseline 2. Project documents • Project schedule • Resource requirements • Risk register • Lessons learned register • Enterprise environmental factors • Organizational project assets	1. Analogous estimating 2. Bottom-up estimating 3. Parametric estimating 4. Three-point estimates 5. Data analysis: • Alternative analysis • Reserve analysis • Cost of quality 6. Decision making: Vote, etc. 7. Project management information system 8. Expert judgment	1. Cost estimates 2. Estimate bases 3. Updates to project documents: • Assumptions log • Risk register • Lessons learned register

Estimating Project Costs

The project cost estimating process is described in high-level steps in the following sections.

Collect Basic Work Information: Scope Baseline

Estimating project costs means estimating the costs required to complete the project scope by executing activities. Therefore, you need the scope baseline to ensure all the needed information is accounted for when estimating costs. Recall that the scope baseline is constituted by the scope statement, WBS, and WBS dictionary. All these components of the scope baseline are useful in estimating the project costs. The *scope statement* will provide the cost-relevant information, such as project- and product-acceptance criteria, assumptions and constraints, product scope description, and project boundaries around

the scope. An example of a cost-related assumption is if we are only counting the direct costs of the project or if we are also counting the indirect costs. The indirect costs are those costs that cannot be directly traced to a specific project and therefore are usually shared by multiple projects and determined by some approved accounting procedure. An example would be the utility bill of the building or a computer network shared by many projects in the company.

The *WBS* will be useful by providing the relationships of project deliverables to different WBS components; that cost is linked to the deliverable, doubling is avoided, and costs can be aggregated or integrated. The WBS dictionary will provide the identification and description of the work.

Work is performed in terms of activities that need resources, and it is the resources that cost.

Collect Resource Information

Information about the project resources can be collected from several sources, such as the following:

- **Project Schedule.** The approved project schedule—i.e., schedule baseline—will give you the required information about the resources needed along the timeline to complete the project work. So, the schedule baseline is crucial to making the cost estimates, as it yields information about the type, amount, and time window of both team and physical resources.
- **Resource Requirements.** This document, generated by the Estimate Activity Resources process, provides detailed information about scheduled resources, such as identification, type, quantity, and so forth.
- **Quality Management Plan.** This document contains quality-related resource information, as it describes the activities and the resources needed to perform those activities in order to meet the planned project quality objectives.
- **Risk Register.** Both kinds of risks—threats and opportunities—have an impact on the cost in the form of risk-mitigation costs and revenues or savings from the opportunities. So, the detailed information about risks provided in the risk register can be used in cost estimates.

Caution! As you learned in the previous chapter, activity resources are estimated by performing the Estimate Activity Resources process. Therefore, the Estimate Costs process should be closely coordinated with the Estimate Activity Resources process.

We also need information on how to keep a process going once it has started.

Collect Information to Facilitate the Process

The information on how to get the process going once started can be extracted from the following sources:

- **Cost Management Plan.** This document can be used as a guide on how to perform the Estimate Cost process; e.g.; methods, units, and precision level to use.
- **Lessons Learned Register.** Record your experience of estimating the cost; e.g.; which technique works the best and so on. The lessons learned register can facilitate team management in the sense that you can use it to record ongoing lessons learned for subsequent use to improve the efficiency and effectiveness of cost estimating.

The following are the information sources for the items that can facilitate or influence the Estimate Costs process:

- **Enterprise Environmental Factors.** Enterprise environmental factors relevant to estimating costs include market conditions and published commercial information that will provide the cost of resources, including team and physical resources such as material and equipment. This will also provide information related to the availability of products and services and their cost and rates. Supply-and-demand conditions can also influence the project costs, as can currency exchange rates and inflation.
- **Organizational Process Assets.** This includes the organization's policies and procedures regarding cost estimates; cost estimating templates; and information from previous projects, including lessons learned.

All the cost-related information that you have collected from input items, as just described, needs to be converted into cost estimates.

Convert Cost-Related Information into Cost Estimates

The cost-related information is converted into cost estimates by using one of the available methods listed in the tools and techniques column of Table 7-3. In general, you can use several methods to estimate the cost, such as analogous estimating, three-point estimates, bottom-up estimating, and so forth. Methods like alternative analysis and decision making are used to choose the methods or the results of cost estimating.

All these techniques have been discussed in this book multiple times, such as in estimating activity durations and in estimating activity resources. Now, we discuss them in the context of estimating project costs and budgeting.

Analogous Estimation. Analogous cost estimation is a technique that evaluates cost-related variables—such as rate, cost of a component, or cost of an activity—from similar components and activities in previous projects, or the cost of a similar project from the past, to estimate the same variable in the current project. This technique is useful when very limited component information is available, especially in the beginning of a project, and is usually used for estimating the gross values and not the detailed component-based values. It's generally less costly and less time consuming than other techniques, but also less accurate. Its accuracy and reliability improve if the person making the estimate is an expert and the components or activities being compared are actually similar.

Parametric Estimation. This is a technique that uses some parameters and the statistical relationships among them to make the estimate. For example, if the unit cost is known, say, from historical data, the cost of the whole package containing a number of units can be calculated. For example, if there are ten identical or similar activities in a work package and it is known that one activity costs $100, then we can say that the whole work package will cost $1,000. This technique can generate quite accurate results depending on the accuracy of the quantity of resources and other data that goes into the estimation.

Bottom-up Estimation. This technique involves estimating the cost of the parts of a component and then aggregating the costs of those parts to calculate the cost of the whole component. By continuing the process, we can aggregate the costs of multiple components and eventually get the cost of the whole project. This technique can generate accurate results when you can generally make a better estimate of a part than the whole, which is usually the case when enough information is available. Of course, statistical uncertainty or accuracy improves as the number of activities, packages, and components increases.

STUDY CHECKPOINT 7.1

Problem:

An activity cost estimate goes like this:

It will take 20 hours of a programmer to write this program. The average rate to hire a programmer is $50 per hour. Therefore, the cost of writing this program, assuming that everything else needed to write the program, such as a computer, is in place, is 20 x $50 = $1,000.

What kind of estimation technique is at work here?

Contingency Reserve Analysis. There are the following two problems associated with estimates:

- Estimates are approximations, and approximations imply uncertainty, which means risk.
- There may be risks not yet identified at the time of making estimates; i.e., cost amount is unknown.

You will need some funds to deal with this situation. What comes to your rescue here is called a *contingency reserve*. The contingency reserve, in general, is an amount of a resource, such as funds, time, and so forth, allocated in addition to the calculated estimates so as to reduce the risk arising from various sources. For example, risk arising from overruns of project objectives to a level acceptable to the performing organization because there was known uncertainty in estimating the cost of a few components. In other words, the contingency reserves are the funds reserved to deal with the events that are anticipated but not certain: known risk with unknown cost.

Depending upon the project, the contingency reserve amount may be determined as a certain percentage of the total project cost estimate, or you can use analytical methods.

Caution! Contingency reserves, also called contingency allowances, usually become part of the project budget, project funding requirements, and cost baseline.

Alternative Analysis, Decision Making, and Project Management Information System (PMIS). All these techniques have been discussed in this book multiple times, such as in Chapter 5. In similar ways, you use alternative analysis to choose one or a few out of many available options of alternative cost estimate methods; you use decision making to take one path when many are available; and you use PMIS to facilitate multiple and alternative methods to estimate cost; e.g.; spreadsheet, simulations, statistical cost analysis, and graphics.

Cost of Quality. This is the cost of implementing the conformance to the planned quality objective and will be discussed in detail in Chapter 10.

Three-point Estimates. Three-point estimates, discussed in Chapter 5 for duration estimates, can also be applied to cost estimates; replace time duration with cost.

Tip Because cost depends on other estimates, the accuracy of cost estimates depends on many other estimates, such as the activity duration estimates and resource requirement estimates, that go into developing the schedule baseline used for making cost estimates. It is important to keep this dependency in mind just in case you need to change any of these other estimates.

STUDY CHECKPOINT 7.2

The pessimistic cost estimate for an activity is $5,000, the optimistic estimate is $3,000, and the most-likely estimate is $4,000. Calculate the expected estimate by using the PERT technique, where the most-likely scenario is given a weight of 4 as compared to the weight of 1 for each of the pessimistic and optimistic scenarios.

By using some of these tools suitable to our project, we get cost estimates.

Output of the Estimate Costs Process

The output of the Estimate Costs process consists of the items discussed in the following sections.

Activity Cost Estimates. These are the quantitative estimates of various costs required to complete the project work. Depending on the project and the stage of the project, the cost estimates may be documented in summary form or in detail. These estimates include costs for all resources needed to complete the project work, including team members, equipment, facilities, information technology, labor directly applied to the project work, material,

services, and so on. Indirect costs and special categories, such as allowances and contingency reserves, must also be included.

Estimate Bases. It's important to document what the bases were of the cost estimates. These may highly depend on the application area of the project. At a higher level, the following elements must be included in the documentation:

- Assumptions made in making the estimates; for example, the labor rate and where this data came from
- Constraints that affected the estimates; for example, a milestone must be met by a certain date
- The methods used to develop the estimate; for example, three-point estimate
- The uncertainty, such as ±10%, and the confidence level must be assigned to an estimate
- What the risks are and how they were included in the cost estimates

Updates. During this process, some existing assumptions and constraints may no longer be true, and some new assumptions and constraints may appear, leading to the need to update the *assumptions log*. This will also affect the risks, thus leading to a *risk register* update. Of course, we should always update the lessons learned register with important lessons learned in performing the process; e.g.; in this case, the cost-estimating techniques that worked the best.

In a nutshell, the outcome of estimating costs will include cost estimates for each project activity and the basis for that estimate, which can be used to determine the project budget.

Determining Project Budget

Determining the project budget is the process of aggregating the cost estimates for all project activities and assigning a timeline to it. Table 7-4 presents the Determine Budget process in terms of its input, tools and techniques, and output. Most of the items in the input to this process have already been described in this chapter. Organizational process assets may include organizational policies and tools for determining the budget. From the business document *business case*, collect information about financial factors that are critical for the project success. Information about target benefits—e.g.; timeframe for materializing the benefits, benefit matrix, values calculations, etc.—can be extracted from the benefit management plan. Both of these business documents were covered in Chapter 2.

Table 7-4. The Determine Budget Process: Input, Tools and Techniques, and Output

Input	Tools and Techniques	Output
1. Project Management Plan: • Cost management plan • Resource management plan 2. Scope baseline 3. Project documents: • Cost estimates • Basis of estimates • Project schedule • Risk register 4. Business documents: • Business case • Benefit management plan 5. Agreements 6. Enterprise environmental factors 7. Organizational project assets	1. Cost aggregation 2. Reserve analysis 3. Historical information review 4. Reconciliation of funding limits 5. Financing 6. Expert judgment	1. Cost baseline 2. Project funding requirements 3. Updates to project documents • Cost estimates • Project schedule • Risk register

Cost aggregation is the technique used to calculate the cost of a whole by summing up the costs of the parts of which the whole—i.e., the project work—is made. You can use the bottom-up estimation technique in WBS to aggregate the costs of the all the components and activities to calculate the total cost of the project, as already explained in the previous section. The timeline assigned to this cost will be important in order to reconcile the expenditure with the funding limits along the timeline. The reconciliation may require rescheduling some activities, hence updating the project schedule documents.

In the previous section, we discussed using *analogous estimates* and *parametric estimates* to estimate the cost of project activities by using the parameters from *historic information*. Models can be built based on these methods to estimate the total cost of the project. The accuracy and reliability of these models depend on the accuracy of the historic parameter information, whether the parameters can be quantified, and whether the models built on these parameters are scalable; i.e., they work for projects of all sizes.

The *reserve analysis* at the budget level includes a management reserve in addition to the contingency reserve, and you must understand the difference between the two. Contingency reserves are funds that can be used to deal with the unplanned events that can potentially transpire—e.g.; in case one or more identified risks occur—whereas management reserves are funds that can be used in the case of unplanned changes that are within the project scope but were missed during planning.

Both contingency reserves and management reserves are part of the project budget and budgeting requirements. The approved budget minus the management reserve is equal to what is called the cost *baseline*. You can add the amount of the management reserve to the cost baseline after it has been used. The cost performance of the project is monitored, measured, and controlled against this baseline.

Financing as a tool in budgeting refers to situations where funding is acquired in stages along the timeline and you have to meet certain conditions—e.g.; show certain project progress—to secure funds at every stage. Funding may not be uniformly distributed over time.

In order to avoid confusion, remember that in every stage or funding period

1. cost baseline = anticipated expenditure + anticipated liabilities; and
2. funding requirements = cost baseline + management reserves

In the process of determining the budget, you may need to update the project schedule, as already mentioned, as well as the cost estimates and risk register, to respond to changes, which may have been applied to related areas.

Caution! Both contingency reserves and management reserves are part of the project budget and budgeting requirements; *cost baseline* is the approved budget minus the management reserve. That means the management reserves will not be used in the calculations of earned value measurements discussed further on in this chapter.

Once the project cost is determined and the budget is approved, you need to control costs as the project progresses.

Controlling Costs

Controlling costs means monitoring and controlling the cost performance and the resulting updates and changes to the costs, budget, and cost baseline of the project. Monitoring and controlling costs has two dimensions to it: expenditure of project funds and the work performed as a result of those expenditures. One major aspect of cost monitoring and controlling is to determine the relationship between the expenditures and the accomplishments. The cost performance is found in this relationship. The other main aspect is to control the changes to the approved cost performance baseline.

Caution! Like any other change, a change in cost and budget must also be processed through the Integrated Change Control process and should only be implemented after its approval.

To be more specific, monitoring and controlling the project costs includes the following:

- **Influence** the factors that can create changes to the approved cost baseline.
- **Monitor** the following:
    - Work performed against the funds expended
    - Variance of cost performance from the approved baseline
- **Prevent** unapproved changes from creeping into implementation, expenditures, and cost reports.
- **Act** to keep cost overruns within the planned acceptable limits.
- **Ensure** the following:
    - Change requests are dealt with in a timely fashion and managed as they occur.
    - Expenditures do not exceed the approved budget; that is, by period and by total amount. Any change to it must be approved before implementation.
- Communicate with the appropriate stakeholders about the cost associated with the approved changes.

Cost is monitored and controlled by using the Control Costs process, presented in Table 7-5 in terms of input, tools and techniques, and output.

Table 7-5. The Control Costs Process: Input, Tools and Techniques, and Output

Input	Tools and Techniques	Output
1. Project Management Plan: • Cost management plan • Cost baseline • Performance measurement baseline 2. Project funding requirement 3. Work performance data 4. Project documents • Lessons learned register 5. Organizational project assets	1. Earned value analysis 2. Variance analysis 3. Trend analysis 4. Reserve analysis 5. To-complete performance index 6. Project management information system	1. Work performance information 2. Cost forecasts 3. Change requests 4. Plan updates • Cost management plan • Cost baseline • Performance measurement baseline 5. Updates to project documents • Cost estimates • Basis of estimate • Assumptions log • Risk register • Lessons learned register

The following are at the core of the controlling costs process:

1. From the *cost management plan*, get information on how to control costs. Apply this information to the following steps.
2. Compare the cost results from project execution in the *work performance data* with the cost baseline by using *variance analysis*. If deviations pass the threshold, create needed *change requests*.
3. Perform an earned value analysis by comparing the project execution results in the *work performance data* against the *performance measurement baseline*. This comparison may generate change requests.
4. Based on these comparisons, perform a *trend analysis*. This will generate the *cost forecast*.
5. The results from the preceding steps will create *work performance information*.
6. Like in many other processes, use the *lessons learned register* to record and subsequently use the lessons learned to improve the process.

Organizational process assets that can influence cost controlling include cost-control related policies, procedures, and guidelines; monitoring and reporting methods; tools used in controlling costs; and the lessons learned database from past projects.

Caution! In general, project progress or performance is measured by comparing the project execution results, in work performance data, against the performance measurement baseline, which is an approved integrated plan for scope, schedule, and cost for the project. Important relevant components of this integrated plan are the *scope baseline, schedule baseline,* and *cost baseline*.

Two common input items to controlling scope, schedule, and cost are work performance data and the performance measurement baseline. In all three processes, we perform performance measurement analysis, using some tools and techniques to generate *work performance information,* a common output item of these three processes.

The elaborate nature of the performance measurement analysis can be seen in the cost-control process. This performance measurement analysis for cost control, using the tools and techniques listed in Table 7-5, is presented in the next section.

Performance Measurement Analysis for Cost Control

As mentioned earlier, cost control includes influencing the factors that can create changes to the cost baseline. But to detect these changes, you need to detect and understand variances or deviations from the cost baseline by monitoring cost performance.

In general, *variance* is a measurable deviation in the value of a project variable or parameter such as cost or schedule from a known baseline or expected value. *Variance analysis* is a technique used to assess the magnitude of the variation in the value of a variable, such as cost, from the baseline or expected value, determine the cause of the variance, and decide whether a corrective action is required. A common technique to assess the cost variance is called the *earned value technique (EVT)*, also called *earned value management (EVM)*. It is a commonly used method of performance measurement that has various forms. Most commonly, it integrates the scope, schedule, and cost performance by comparing the baselines with the actual progress made. For example, you calculate the cumulative value of the budgeted cost of work performed in terms of the originally allocated budgeted amount and compare it to the following:

1. Budgeted cost of work scheduled—that is, planned
2. Actual cost of work performed

Don't worry if these terms sound confusing right now; I will go through an example soon. However, as you will see, the greatest difficulty in understanding EVT (or EVM) stems from the coupling of cost and schedule. You must realize by now that the project cost and the project schedule are inherently related to each other. *Schedule* refers to performing certain work over a certain time period, whereas *cost* refers to the money spent to perform the work on a project (or a project activity) over a certain period of time. The relationship between cost and schedule can be realized by understanding that it costs money to perform a schedule activity. Also, the "time is money" principle is at work here. For example, a project activity can be looked upon in terms of an amount of work that will be needed to complete it or in terms of its monetary value, which will include the cost of the work that needs to be performed to complete the activity.

Caution! As you delve into EVM, remember there are only three variables or parameters that need to be monitored and developed closely: planned value (PV), earned value (EV), and actual cost (AC). The rest of the parameters and the earned value analysis are largely based on these three fundamental parameters.

The EVM involves calculating some variables where you will see the interplay of schedule (work) and cost. I will work through a running example to help you understand the terminology used here.

Example: Assume you are a project manager for the construction of a 16-mile road. Further assume that the work is uniformly distributed over 12 weeks. The total approved budget for this project is $600,000. At the end of the first four weeks of work, $125,000 has been spent, and four miles of road has been completed.

I will use this example to perform the cost performance analysis and the schedule performance analysis in terms of cost.

Cost Performance

Cost performance refers to how efficiently you are spending money on the project work, measured against the expectations set in the project management plan—that is, the cost baseline. The total cost approved in the baseline is called the *budget at completion (BAC)*.

Note The variables discussed here, such as BAC, EV, and AC, can be calculated either for the whole project or for a part of the project, such as a project activity.

Budget at Completion (BAC). This is the total budget authorized for performing the project work (or a project activity), also called the *planned budget*. In other words, it is the cost originally estimated in the project management plan. You use this variable in defining almost all the following variables. In our example, the value of BAC is $600,000.

Earned Value (EV) or Budgeted Cost of Work Performed (BCWP). This is the value of the actually performed work expressed in terms of the approved budget for a project or a project activity for a given time period. In this variable, you see the relationship of schedule (work) and cost in action. BAC represents the total value of the project. But when you perform only some work on the project, you have earned only some of that total value, and the earned value is proportional to the fraction of the total work performed, as shown by the formula here:

$$EV = BAC \times (\text{work completed} / \text{total work required})$$

So, in our example, EV can be calculated as:

$$EV = \$600{,}000\ (4\ \text{miles}/16\ \text{miles}) = \$150{,}000$$

This is the earned value of the work performed so far, which may or may not be equal to the actual money that you spent to perform this work.

Actual Cost (AC) or Actual Cost of Work Performed (ACWP). This is the total cost actually incurred performing the work for a project until a specific point on the timeline. In our running example, $125,000 has already been used up to this point. So, the actual cost at this point in time is $125,000. This cost is to be compared with the earned value to calculate the *cost variance* and cost performance.

Cost Variance (CV). This is a measure of cost performance in terms of the deviation of reality from the plan, and it is obtained by subtracting the actual cost (AC) from the earned value (EV), as shown in the formula here:

$$CV = EV - AC$$

So, in our example, CV can be calculated as shown here:

$$CV = \$150{,}000 - \$125{,}000 = \$25{,}000$$

The expected value of CV is zero because we expect the earned value to be equal to the actual cost. A positive result indicates better cost performance

than expected, whereas a negative result indicates worse cost performance than expected. Deviation is one way of comparison, and ratio is another.

Cost Performance Index (CPI). Earned value represents the portion of the work completed, and the actual cost represents the money spent. So, the CPI indicates whether you are getting a fair value for your money. This is a measure of the cost efficiency of a project calculated by dividing earned value (EV) by actual cost (AC), as shown in the formula here:

$$CPI = \frac{EV}{AC}$$

So, the CPI for our example can be calculated as:

CPI = $150,000 / $125,000 = 1.2

This means you are getting $1.20 worth of performance for every dollar spent. A value of CPI greater than one indicates good performance, whereas a value less than one indicates bad performance. The expected value of CPI is one.

Back in our example, both the CV and the CPI indicate that you are getting more value for each dollar spent. Hold back a little before opening the champagne, though. If you read the text of our example again, note that 4 out of 12 weeks have already passed, and only 4 out of 16 miles of road have been built. That means that only one-fourth of the work has been accomplished in one-third of the total scheduled time. This means we are lagging behind in our schedule. Although cost performance is good, schedule performance needs to be investigated, too; remember, time is money!

Schedule Performance in Terms of Cost

Schedule performance refers to how efficiently you are executing your project schedule as measured against the expectations set in the project management plan. It can be measured by comparing the earned value to the planned value, just like cost performance is measured by comparing the earned value to the actual cost. *Planned value* refers to the value that we planned to create in the time spent so far.

Planned Value (PV) or Budgeted Cost for the Work Scheduled (BCWS). This is the authorized cost for the scheduled work on a project or a project activity up to a given point on the timeline. The planned value is also called the *budgeted cost for the work scheduled (BCWS)*. PV is basically how much you were authorized to spend in the fraction of schedule time spent so far, as shown in the formula here:

PV = BAC × (time passed / total schedule time)

Therefore, the planned value for the project in our example at the end of the first four weeks is calculated as shown here:

$$PV = \$600{,}000 \times (4 \text{ weeks} / 12 \text{ weeks}) = \$200{,}000$$

So, PV represents the planned schedule in terms of cost. You can calculate the schedule performance by comparing the planned schedule to the performed schedule in terms of cost.

Caution! Note that the total planned value (PV) of the project is the same as the budget at completion (BAC).

Schedule Variance (SV). This is the deviation of the performed schedule from the planned schedule in terms of cost. No confusion is allowed here because you already know that the schedule can be translated to cost. SV is calculated as the difference between EV and PV, as shown in the formula here:

$$SV = EV - PV$$

So, the SV in our example can be calculated as:

$$SV = \$150{,}000 - \$200{,}000 = -\$50{,}000$$

The negative value means we are behind schedule. Deviation represented by schedule variance is one way of comparison, and ratio represented by schedule performance index is another.

Schedule Performance Index (SPI). Earned value represents the portion of work completed in terms of cost, and planned value represents how much work was planned by this point in time in terms of cost. So, the SPI indicates how the performed work compared to the planned work. This is a measure of the schedule efficiency of a project calculated by dividing earned value (EV) by planned value (PV), as shown in the formula here:

$$SPI = \frac{EV}{PV}$$

So, the SPI for our example can be calculated as shown here:

$$SPI = \$150{,}000 / \$200{,}000 = 0.75$$

This indicates that the project is progressing at 75 percent of the planned pace—not good.

You should note that all these performance variables except the BAC are calculated at a given point in time. As shown in Figure 7-2, you can maintain a graphic that presents the values of these variables against points in time as the project progresses. Note that the value of the BAC does not change with time because it is the cost at completion time. Further note that given the BAC, the PV can be calculated at any point in time, even before the project execution starts. EV and EC are accumulated as the project execution progresses.

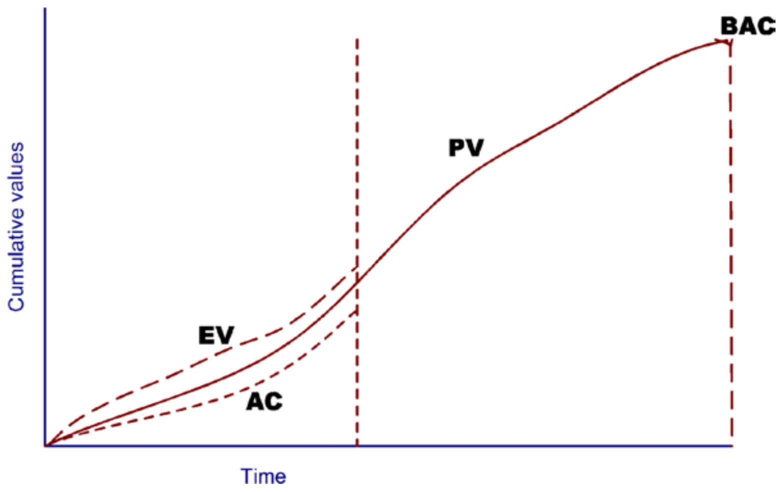

Figure 7-2. The behavior of some performance variables as the project progresses in time. The variable BAC is independent of time.

By using the variables discussed so far, you can monitor the project performance as the time progresses. Not only that, you can also make predictions about future performance based on past performance.

Forecasting Techniques

Forecasting refers to predicting some information about the project in the future based on its performance in the past. The forecasting is regularly updated as the project progresses and more data of the past performance becomes available.

Estimate to Complete (ETC) at Budgeted Rate. This is the prediction about the expected cost to complete the remaining work for the project or for a project activity. The future work is assumed to be completed at the budgeted rate. Therefore, the value of the ETC is obtained by subtracting the earned value (EV) from the budget at completion (BAC), as shown in the formula here:

$$ETC = BAC - EV$$

So, in our example, the value of ETC can be calculated as:

$$ETC = \$600,000 - \$150,000 = \$450,000$$

This is true if the current variances are seen as atypical and the future performance is expected to be as planned. If the current trend, however, continues, then we need to take CPI into account, as shown next.

Estimate to Complete (ETC) at the Present CPI. This is the prediction about the expected cost to complete the remaining work at the present CPI. Therefore, in that case, the ETC is given by:

$$ETC = \frac{BAC - EV}{CPI}$$

The next question that can be asked about the future is how much it will cost to complete the whole project.

STUDY CHECKPOINT 7.3

In our running example, calculate the ETC at the present CPI.

Estimate at Completion (EAC) at the Budgeted Rate. This is the estimate made at the current point in time for how much it will cost to complete the whole project or a project activity from beginning to end. It is assumed that the future work will be performed at the budgeted rate. Therefore, the value of the EAC is obtained by adding the value of ETC at budgeted rate to AC, as shown in the formula here:

$$EAC = AC + ETC \text{ (budgeted rate)}$$

Accordingly, the value of EAC for our example can be calculated as:

EAC = $125,000 + $450,000 = $575,000

Another useful prediction to be made is how much performance you need in the future to complete the remaining work within budget.

STUDY CHECKPOINT 7.4

Prove the validity of the following equation:

$$EAC = AC + BAC - EV$$

EACs calculated thus far are correct under the assumption that in the future the cost will be incurred as it was budgeted or performance will be made as planned. If, however, the current variance trend is assumed to continue, then EAC is calculated as discussed next.

Estimate at Completion (EAC) at the Present CPI. This is the estimate made at the current point in time for how much it will cost to complete the whole project or a project activity from beginning to end. It is assumed that the future work will be performed at the current CPI. Therefore, EAC is calculated as follows:

$$EAC = AC + ETC(\text{at current CPI})$$

➔

$$EAC = AC + \frac{BAC - EV}{CPI}$$

STUDY CHECKPOINT 7.5

In our running example, caluclate EAC at the present CPI.

As was said earlier, performance is an integrated measure of progress in the areas of scope, schedule, and cost. Just measuring one of these parameters may be misleading. For example, in our running example, we are performing better in cost but poorly in schedule. This is why sometimes EAC is measured by taking into account both CPI and SPI, as shown here:

$$EAC = AC + \frac{BAC - EV}{CPI \times SPI}$$

STUDY CHECKPOINT 7.6

In our running example, calculate EAC at the present CPI and SPI.

To-Complete Performance Index (TCPI). This is the variable used to predict the future performance needed to finish the work according to a specified goal; for example, either within the planned budget (BAC) or at the completion cost currently predicted (EAC). If the goal is to complete it within BAC, it is calculated as the ratio of the remaining work to the remaining budget, as shown in the formula here:

$$TCPI = \frac{Remaining\ work}{Remaining\ funds} = \frac{BAC - BCWP}{BAC - ACWP} = \frac{BAC - EV}{BAC - AC}$$

Therefore, the value of TCPI in our example can be calculated as:

TCPI = (\$600,000 – \$150,000) / (\$600,000 – \$125,000)
= 450,000 / 475,000 = 0.95 = 95%

If it is realized that BAC is not attainable, then it is replaced with EAC. Accordingly, TCPI will be given by the following:

$$TCPI = \frac{Remaining\ work}{Required\ funds} = \frac{BAC - EV}{EAC - AC}$$

Table 7-6 summarizes most of these performance variables.

Table 7-6. Performance Variables Used in the Earned Value Technique Analysis

Variable	Abbreviation	Description	Formula
Budget at completion	BAC	Total planned cost	None
Earned value or budgeted cost of work performed	EV or BCWP	Fraction of the completed work in terms of the planned budget at a given point in time	EV = BAC × (Work completed / Total work required)
Actual cost	AC or ACWP	The money spent on the work until a given point in time	The sum of all the costs until a given point in time
Cost variance	CV	The difference between what you planned to spend and what is actually spent until a given point in time	CV = EV – AC
Cost performance index	CPI	The work performed per actual cost	CPI = EV / AC
Planned value or budgeted cost of work scheduled	PV or BCWS	The fraction of work planned to be completed at a given point in time	PV = BAC × (Time passed / Total schedule time)
Schedule variance	SV	The difference between the work actually completed and the work planned to be completed at a given point in time	SV = EV – PV
Schedule performance index	SPI	The actual work performed per planned work performed in terms of cost	SPI = EV / PV
Estimate to complete	ETC	Estimate of what will be spent on the remaining project (or a project activity) based on the performance so far and the planned cost	ETC = BAC – EV
Estimate at completion	EAC	Estimate of what will be spent on the whole project (or a project activity) based on the performance so far and the planned cost	EAC = ETC + AC
To-complete performance index	TCPI	Calculates the efficiency: remaining work per remaining funds	(BAC – EV) / (BAC – AC)

Caution! Depending on what information in known, the variables just discussed can be expressed in different equations, as shown by Study Checkpoint 7.4. But sticking the definition-side variable, it can be realized that all these different forms of equations for a variable are all equivalent.

The analysis presented here is a good demonstration of how schedule and cost are coupled together, and both obviously depend upon scope. The success of a project depends on completing the project according to the schedule—with full planned scope and within the planned cost. These three parameters, scope, schedule, and cost, are intrinsically related to one another.

Scope, Schedule, and Cost: The Triple Constraint

The nutshell of running a project is delivering the scope according to some schedule, and it's going to cost someone. Completing a project successfully includes delivering the planned scope according to the planned schedule and within the planned budget. The fundamental parameters for budget and schedule are cost and time, respectively: budget is the cost with a timeline, and schedule is determined from the time estimates for completing the schedule activities defining the scope. So scope, schedule, and cost are the heart of any project. These three project parameters also comprise a triple constraint that is a framework for evaluating competing demands. A triple constraint can be depicted as a triangle, with each side representing one of these three parameters. Figure 7-3 shows the triple constraint for the scope, schedule, and cost. This means if one of these parameters changes, at least one of the other two must change as well.

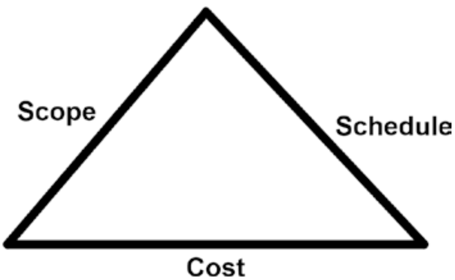

Figure 7-3. Triple constraint: scope, schedule, and cost. You cannot change the length one side of the triangle without changing the length at least one of the other two sides.

Caution! The present version of PMBOK does not formally discuss the triple constraint of scope, cost, and schedule. However, the formal name aside, it remains a fact that scope, schedule, and cost are tightly coupled, as reflected by the integrated performance measurement baseline and the earned value analysis. Therefore, the discussion in this section is still valuable.

In Figure 7-3, you cannot change the length of one side of the triangle without changing the length of at least one of the other two sides. For example, assume you are being interviewed by a functional manager for a project manager position. Don't be surprised if you are asked a question based on the following situation:

1. The project is way behind the schedule.
2. No extra resources, such as money or project team members to perform activities, are available.
3. You have to implement all the planned features.

The question is, what will you do to meet the deadline that is approaching within a week? From a project management viewpoint, this situation is a good example of the triple constraint. The project is behind schedule, which means there is a schedule change (or a change in time available to finish the remaining project). Recall project scheduling from Chapter 5—your options in this situation are pretty limited, such as applying lead and lags, float, and smoothing techniques. In most of these situations, at least one of the other two parameters must change. If you want to meet the deadline, either you should be allotted more funds to hire more resources or the scope of the project should be changed, which means some of the features would be left out. Depending upon the knowledge level of the functional manager about project management, this answer might not get you the job, but as a project manager, you must stand your ground. Project management is not magic; it involves dealing with cold, hard reality in a realistic way, thereby establishing clear and achievable objectives.

Note While considering the cost-schedule-scope constraint, you should also remember techniques like resource leveling and smoothing, applying leads and lags, and schedule compression techniques, such as crashing and fast tracking, discussed in Chapter 5. Also remember that those techniques do not guarantee that no additional cost (or resources) will be required.

You can see the relationship of the triple constraint with quality by recalling that a high-quality project delivers the required product on time and within the planned scope and budget. Therefore, while balancing between these three constraints, the quality (and, as a result, customer satisfaction) might be affected. The triple constraint is also a good example of how one change can give rise to other changes across the project. This highlights the importance of managing and controlling changes.

Changes to scope, schedule, and cost are controlled using the Control Scope, Control Schedule, and Control Cost processes, respectively. These three processes are at the center of the project action. As Figure 7-4 illustrates, they take work performance data from the project execution process, the Direct and Manage Project Work process, and the generate work performance information process, which are used by the Monitor and Control Project Work process to generate the work performance reports.

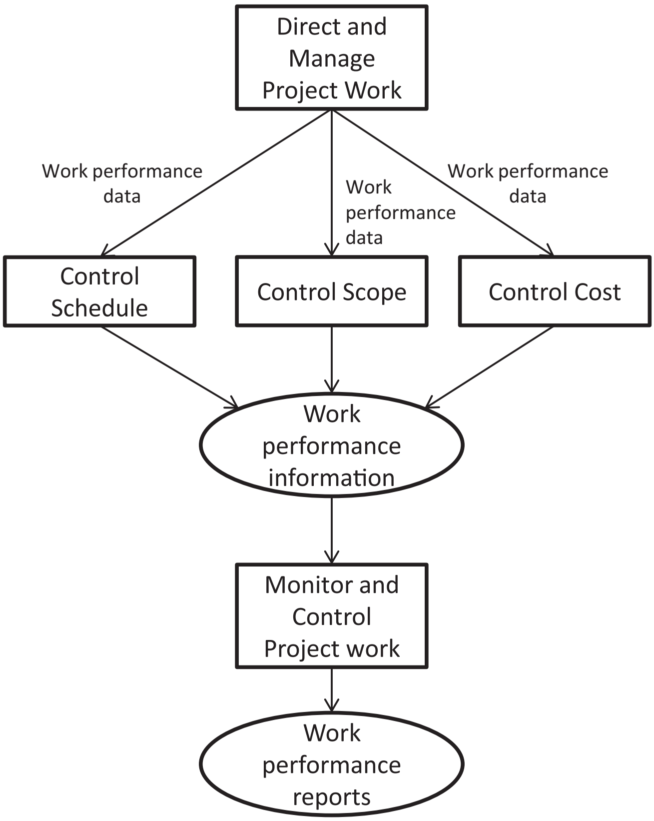

Figure 7-4. The processes to control scope, schedule, and cost in a big picture

STUDY CHECKPOINT 7.7

Q. Name three processes that convert the work performance data into work performance information.

The three most important takeaways from this chapter are the following:

1. Project cost is estimated from project scope, project schedule, and project resource requirements, and project budget is project cost along the timeline.
2. Cost control involves converting the cost-related work performance data into work performance information by comparing the data with the integrated baseline: scope baseline, schedule baseline, and cost baseline.
3. This comparison is made by using earned value management (EVM), in which there are several variables based on three fundamental parameters, namely actual cost (AC), earned value (EV), and planned value (PV).

Summary

Cost management consists of developing a cost management plan, estimating costs, determining budget, and controlling costs. You use the scope baseline to estimate the monetary resources needed to complete the project activities. The activity cost estimates and project schedule are used to determine the project budget, which is the cost with a timeline attached to it. The budget includes the aggregated cost, contingency reserve, and management reserve with a timeline. These elements are also included in the project funding requirements. The approved budget minus the management reserve is called cost *baseline*. The cost performance of the project is monitored, measured, and controlled against the integrated baseline that includes this cost baseline.

The three fundamental parameters—scope, schedule, and cost—are intrinsically related to each other. For example, if you change one of them, one or both other parameters will change as well. This constraint is known as a triple constraint. Therefore, the project cost performance is measured by comparing the project execution results against the performance measurement baseline, which is an approved integrated plan for scope, schedule, and cost for the project. In other words, the performance baseline includes scope baseline, cost baseline, and schedule baseline.

Road Ahead. In Chapter 2, we talked about project stakeholders in some detail, and all through the book we have been making references to them. As you know, everyone from the project sponsor to you, your team, and the customer is a stakeholder. Without stakeholders, there would be no project. This underlines the importance of stakeholder management. So, in the next chapter, we will explore project stakeholder management.

Exam's Eye View

Comprehend

- The project charter, project schedule management plan, and project risk management plan are used to develop the project cost management plan.
- The scope baseline, schedule baseline, and resource requirements are the main inputs to make cost estimates for activities, which are aggregated to determine the project budget.
- The accuracy of cost estimates depends on the accuracy of other estimates, such as activity duration estimates and the activity resource requirements estimates.
- The project budget includes the aggregated cost with timeline, contingency reserves, and management reserves; this composition also makes budgeting requirements.
- Monitoring and controlling includes monitoring and controlling project performance and managing the resulting changes.
- The three project parameters—cost, schedule, and scope—form a triple constraint, which means if one of these three parameters changes, at least one of the other two must change.
- Performance measurement baselines and work performance data are the common input to controlling the scope, schedule, and cost, and work performance information and change requests are the common output.
- Project cost performance is measured by comparing the project results from work performance data against the performance measurement baseline: scope baseline, schedule baseline, and cost baseline.

Look Out

- The probability of influencing the project cost is maximum early in the project.
- The approved budget minus the management reserve is equal to what is called the cost *baseline*. You can add the amount of management reserves to the cost baseline after it has been used.
- Planned value (PV), earned value (EV), and actual cost (AC) are the three key parameters that need to be monitored closely. The rest of the earned value analysis is based on these three fundamental parameters.
- Cost variance (CV) is calculated by subtracting the actual cost (AC) from the earned value (EV), and not from the planned value (PV).
- Schedule variance (SV) and schedule performance index (SPI) are calculated in terms of cost: EV and PV.
- It is possible for CV and SV to run in opposite directions—for example, CV has a positive value when SV has a negative value.
- Total planned value (PV) of the project is the same as the budget at completion (BAC)

Memorize

- Project budget is the time-phased project cost obtained by aggregating the individual activity costs.
- Contingency reserves are the funds that can be used to deal with the unplanned events that can potentially transpire—e.g.; in case of one or more identified risks occur—whereas management reserves are the funds that can be used in case of unplanned changes that are within the project scope but were missed during planning.
- Three-point estimations and analogous estimation usually are less time consuming but also less accurate than parametric estimation and bottom-up estimation.
- In every stage or funding period:

  Cost baseline = anticipated expenditure + anticipated liabilities

  Funding requirements = cost baseline + management reserves
- For cost performance analysis:

  EV = BAC × (Work completed / Total work required)

  CV = EV – AC

  CPI = EV / AC
- For schedule performance analysis:

  PV = BAC × (Time passed / Total schedule time)

  SV = EV – PV

  SPI = EV / PV

  EAC at the budgeted rate = AC + BAC - EV

$$EAC\ at\ current\ CPI = AC + \frac{BAC - EV}{CPI}$$

$$EAC\ at\ current\ CPI\ and\ current\ SPI = AC + \frac{BAC - EV}{CPI \times SPI}$$

$$TCPI = \frac{BAC - EV}{BAC - AC}$$

Review Questions

1. Your project is in the planning stage. You first want to make the cost estimates for the planned project activities, and then you want to aggregate those costs. Which process will you perform first?

   a. Determine Budget

   b. Plan Resource Management

   c. Estimate Costs

   d. Plan Cost Management

2. Which of the following processes will you perform first?

   A. Estimate Activity Resources

   B. Determine Budget

   C. Estimate Costs

   D. Develop Schedule

3. Your supervisor has asked you to put some contingency reserves into your project plans. Which of the following is not true about contingency reserves?

   A. These are the funds and not the time.

   B. These are included in the cost baseline.

   C. These are included in the budget.

   D. These are included in the project funding requirement.

4. You are in the process of developing the cost baseline for your project. What is the name of this process?

   A. Determine Budget

   B. Develop Cost Baseline

   C. Estimate Costs

   D. Control Costs

5. Assume that you are the project manager for the construction of a 15-mile road. Further assume that the work is uniformly distributed over 12 weeks. The total approved budget for this project is $600,000. At the end of first three weeks of work, $160,000 has been spent, and five miles of road have been completed. What is the earned value of the project at the end of the first three weeks?

   A. $160,000

   B. $200,000

   C. $150,000

   D. $600,000

6. Assume that you are the project manager for the construction of a 15-mile road. Further assume that the work is uniformly distributed over 12 weeks. The total approved budget for this project is $600,000. At the end of first three weeks of work, $160,000 has been spent, and five miles of road have been completed. What is the planned value of the project at this point in time?

   A. $160,000

   B. $200,000

   C. $150,000

   D. $600,000

7. Assume that you are the project manager for the construction of a 15-mile road. Further assume that the work is uniformly distributed over 12 weeks. The total approved budget for this project is $600,000. At the end of first three weeks of work, $160,000 has been spent, and five miles of road have been completed. What is the cost variance?

   A. $40,000

   B. $50,000

   C. –$40,000

   D. $120,000

8. Assume that you are the project manager for the construction of a 15-mile road. Further assume that the work is uniformly distributed over 12 weeks. The total approved budget for this project is $600,000. At the end of first three weeks of work, $160,000 has been spent, and five miles of road have been completed. What is the schedule variance?

   A. $40,000

   B. $50,000

   C. Three weeks

   D. Twelve weeks

9. A project has a CPI value of 1.25 and an SPI value of 1.33. It means which of the following?

   A. The project is making slower progress and costing more than planned.

   B. The project is making faster progress and costing less than planned.

   C. The project is making slower progress and costing less than planned.

   D. The project is making faster progress and costing more than planned.

10. Project cost performance is measured by comparing the project results from work performance data against the integrated performance measurement baseline. Which of the following are the three elements of this integrated performance measurement baseline?

    A. Scope baseline, time baseline, and cost baseline

    B. Scope baseline, schedule baseline, and quality baseline

    C. Scope baseline, time baseline, and quality baseline

    D. Schedule baseline, scope baseline, and cost baseline

11. An influential stakeholder has submitted a request for completing the project earlier than planned in less time. What are the two parameters that are most likely to be affected by this time change?

    A. Schedule and deliverables

    B. Quality and risk

    C. Cost and scope

    D. Cost and budget

12. You are managing a project in biotechnology code named Mitochondria Eve. You need work performance measurements or information to write the performance reports. Which process(es) will you run?

    A. Monitor and Control Project Work

    B. Control Scope, Control Schedule, and Control Costs

    C. Develop Project Work Performance Report

    D. Direct and Manage Project Work

13. The cost of a project activity is estimated to be $500 with ±10% accuracy. What is the estimated range of cost?

    A. $450–$550

    B. $490–$510

    C. $475–$525

    D. $500–$550

14. Which of the following is not listed as an input item in PMBOK to develop the cost management plan?

    A. Project charter

    B. Schedule management plan

    C. Risk management plan

    D. Quality management plan

CHAPTER

8

Managing the Stakeholders

The objectives covered in this chapter make up 9 percent of the exam, equivalent to about 12 questions. Study the whole chapter in detail.

It's enough to just remember the name of the input, tools and techniques, and outputs. You should know what is in a given input item that the given process uses and how it helps in generating the output, and what a given tool or technique does in a given process.

You should understand very well the concepts and methods of stakeholder mapping and representation, classification models, and stakeholder engagement.

CAPM Exam Objectives

Project Stakeholder Management:

1. Understand the four project management processes in the project stakeholder management knowledge area.
2. Identify the input, tools and techniques, and outputs defined in the four project stakeholder management processes.
3. Recognize key stakeholders roles and needs.
4. Identify the key concepts and benefits of stakeholder management.

P. Sanghera, *CAPM® in Depth*, https://doi.org/10.1007/978-1-4842-3664-2_8

Without project stakeholders, there is literally no project. Your project is doomed to fail without successful project stakeholder management. Before asking "What is stakeholder management?" let's recall who the project stakeholders are. As discussed in Chapter 2, the enthusiasm, anxieties, fears etc. about the project varies with different stakeholders. Accordingly, they will have differing needs and expectations. One of the key project management focuses on which project success depends is achieving stakeholder satisfaction by meeting their needs and expectations while remaining aligned with project objectives. A key to keeping stakeholder expectations aligned with project objectives and meeting those expectations is to keep stakeholders engaged in the project. Project managers have little, if any, control over the stakeholders. So, stakeholder management is all about stakeholder engagement.

To learn about project stakeholder management, we will explore three avenues: identify stakeholders, plan stakeholder engagement, and manage and monitor stakeholder engagement.

Project Stakeholder Management: Big Picture

Project stakeholder management is all about getting stakeholders engaged in the project in order to get their support. This knowledge area is comprised of the four processes summarized in Table 8-1. A high-level and simple view of the interaction between these processes is shown in Figure 8-1.

Table 8-1. Processes of Project Stakeholder Management Mapped to the Process Groups of Major Outputs.

Resource Management Process	Process Group	Major Output	Performed
Identify Stakeholders	Initiating	Stakeholder register	Throughout the project as needed
Plan Stakeholder Engagement	Planning	Stakeholder engagement plan	Throughout the project periodically
Manage Stakeholder Engagement	Executing	Issues, change requests	Throughout the project
Monitor Stakeholder Engagement	Monitor and Control	Work performance information	Throughout the project

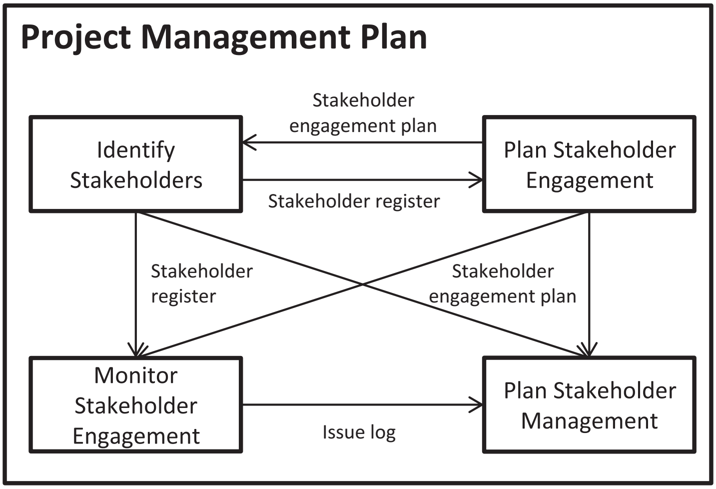

Figure 8-1. Big picture of managing stakeholders

Note With the exception of integration management, there is no knowledge area other than stakeholder management that has processes in all the project stages before closing the project. This reflects the significance of stakeholder management.

Before we can get stakeholders engaged in the project, we need to identify them.

Identifying the Project Stakeholders

As mentioned in Chapter 1 and explained in Chapter 2, project stakeholders are individuals and organizations whose interests are affected (positively or negatively) by the project's execution and completion and/or who can influence or impact the project. In other words, a project stakeholder has something to gain from the project or something to lose to the project. Accordingly, stakeholders fall into two broad categories: positive stakeholders, who will normally benefit from the success of the project, and negative stakeholders, who see some kind of disadvantage coming from the project. The implications obviously are that the positive stakeholders would like to see the project succeed, and the negative stakeholders' interests would be better served if the project were delayed or cancelled altogether. For example, your city mayor might be a positive stakeholder in a project to open a Walmart store in your neighborhood because it brings business to the city, whereas some local business leaders might look at it as a threat to their businesses and thereby may act as negative stakeholders.

Negative stakeholders are often overlooked by the project manager and the project team, which increases the project risk. Ignoring positive or negative project stakeholders will have a damaging impact on the project. Therefore, it's important that you, as a project manager, start identifying the project stakeholders early on in the project. The different project stakeholders might have different and conflicting expectations that you need to analyze and manage.

Identifying all the project stakeholders might be a difficult task, but the obvious ones include the project manager, program manager, portfolio manager, customers and users, project sponsor, project management office, project team, operations management, sellers and business partners, and functional managers related to the project. In addition to these key stakeholders, discussed in Chapter 2, there can be a number of other less obvious stakeholders inside and outside of your organization. Depending upon the project, these might include investors, sellers, contractors, family members of the project team members, government agencies, media outlets, lobbying organizations, individual citizens, and society at large.

It is critical for the success of the project that you identify both positive and negative stakeholders early on in the project, understand and analyze their varying and conflicting expectations, and manage those expectations throughout the project.

Table 8-2 presents the Identify Stakeholders process in terms of its input, tools and techniques, and output. Identifying stakeholders includes the following:

- Identify individuals and organizations that can influence the project and/or be impacted by the project.
- Document relevant information about the individuals and organizations and about their interests and involvement in the project and so forth.
- Document how these individuals and organizations can influence the project and how they can be impacted by the project.
- Determine the level of importance of these stakeholders.

Table 8-2. The Identify Stakeholders Process: Input, Tools and Techniques, and Output

Input	Tools and Techniques	Output
1. Project charter 2. Project Management Plan: • Communications management plan • Stakeholder engagement plan 3. Business documents: • Business case • Benefit management plan 4. Project documents: • Requirement documentation • Change log • Issues log • Agreements 5. Enterprise environmental factors 6. Organizational project assets	1. Data gathering: • Questionnaires and surveys • Brainstorming 2. Data analysis: • Stakeholder analysis • Document analysis 3. Data representation: • Stakeholder mapping and representation 4. Expert judgment 5. Meetings	1. Stakeholder register 2. Change requests 3. Project management updates: • Communications management plan • Stakeholders engagement plan • Requirement management plan • Risk management plan 4. Project document updates: • Issues log • Assumptions log • Risk register

As mentioned earlier, stakeholder identification is necessary in order to manage stakeholder expectations and to manage their influence on the project. They can influence various aspects of the project, such as definition, changes, execution, deliverables, and ultimately its success. They may come from inside the organization with different levels of authority or from outside the organization.

Identifying stakeholders is an iterative process—that is, you might have to perform the identification over and over again because some old stakeholders may become irrelevant and some new stakeholders may appear during the life of the project. Because identifying and analyzing the stakeholders and managing their expectations and influence is so critical to the success of the project, you should start this task early on in the project.

In order to identify the stakeholders, we gather, analyze, and present the data or information about the stakeholders.

Gathering Data

You can start by collecting information about stakeholders from the input items listed in Table 8-2.

The Project Charter. The project charter helps to identify key stakeholders with responsibilities by revealing the internal and external individuals and groups who are either directly involved in the project or potentially will be impacted by it. The project sponsor, customers, and departments of the performing organization participating in the project are some examples of stakeholders identified by the project charter.

Business Documents. The *business case* document reveals the project objectives and the initial list of related stakeholders. From the *benefit management plan* you can extract information about the stakeholders who would benefit from the project outcome.

Project Management Plan. As stakeholder management is closely coupled with communication management, you can extract considerable information about project stakeholders from the *communication management plan*. Also, if the *stakeholder engagement plan* is already developed, it will contain information about stakeholders.

Project Documents. The *change log* and *issues log* may reveal new stakeholders or changed project relations with an existing stakeholder. Also, from the *requirement documentation* you can extract or derive the stakeholder information.

Procurement Documents. If the project originated from procurement activity, then the procurement documents, such as the contract, will be useful to identify the stakeholders. If this project is going to use procurement in order to produce part of its product, even then the procurement documents will help to identify some stakeholders, such as sellers and suppliers.

Advanced Data Gathering. In conjunction with and in addition to simple information and data collection from input items, we can use some *data-gathering techniques* to identify new stakeholders and also get more information about already identified stakeholders. These techniques include questionnaires, surveys, and brainstorming. You can also use document-analysis techniques for this purpose. These techniques are described in Chapter 10.

Once the data about stakeholders is collected, it needs to be analyzed to extract the useful information from it, which will then need to be appropriately presented.

Stakeholder Data Analysis

Stakeholder analysis is an activity to analyze data about the stakeholders to extract useful and relevant information. The following are three major steps:

1. **Identify.** Identify all potential stakeholders and the important characteristics of each identified stakeholder, such as the following:

    a. **Name, Department, and Role.** For example, Dr. John Serri, Vice President, Research and Development

    b. **Interest in the Project.** Why should the stakeholder be interested in the project? Is the stakeholder seeking to benefit or is the stakeholder threatened?

    c. **Right, Ownership, Contribution.** What are the legal and moral rights of the stakeholder, ownership of assets, and so forth, and how and how much can the stakeholder contribute to the project?

    d. **Knowledge Level.** What is the knowledge level of the stakeholder, especially about the project and in the application area of the project? In other words, how and how much can the stakeholder's knowledge help or hurt the project?

    e. **Expectations.** What are the stakeholder's needs and expectations of the project?

    f. **Kind and Level of Influence.** In which way and how much can the stakeholder influence the project to impact its outcome?

2. **Assess.** Make an assessment of how a stakeholder is going to react to various situations in the project. This will help in your preparation to influence them to get their support to enhance the chances of project success.

3. **Classify.** With this information at hand, we can classify—i.e., categorize—the stakeholders using data-presentation techniques that will help you build an appropriate relationship with the stakeholders.

Data Presentation

An example of a data-presentation technique is mapping stakeholders using various criterion. When there are so many stakeholders, it's important for effective stakeholder management to classify and prioritize the stakeholders. This will help with efficient use of management efforts, including communication and expectations management, and also building appropriate relationships with stakeholders. For example, an obvious classification is positive and negative stakeholders. For more sophisticated classifications, there are several criteria and models, including the following:

Direction of Influence. This model classifies stakeholders according to the magnitude and direction of their influence, as follows:

- **Upward.** For whom the project is being performed—e.g.; project sponsor, customer organization, and senior management or performing organization
- **Downward.** Project team or other people working for the project on a temporary basis, such as knowledge or skill specialists
- **Outward.** Stakeholders outside the project team; e.g.; end users, suppliers, and regulators
- **Sideward.** Other project managers or middle managers in competition with this project; e.g.; for resources

Power/Interest Grid. In this model you place the stakeholders on a two-dimensional plot: power/authority level versus interest level. For example, if a powerful stakeholder has a lot of interest in the project, he is of great priority. If, on the other hand, a stakeholder lacks interest in the project, then he potentially is not going to influence the project that much, even if he has a lot of authority.

Power/Influence Grid. This model plots the stakeholders in a two-dimensional space: authority level versus ability to influence the project.

Influence/Impact. This model plots the stakeholders in a two-dimensional space: ability to influence the project versus ability to cause changes in the project planning and execution, and hence in the final outcome. For example, a project stakeholder may be highly involved (high influence) in the project but have no ability to impact the project, such as influencing the changes in the project. In that case, this stakeholder is of lower priority than the stakeholder who has high involvement and high impact.

Stakeholder Cube. This model plots the stakeholders in a three-dimensional space: influence, impact, and power.

Salience Model. This model classifies stakeholders based on their multiple characteristics, such as the ability to impose their will (power); the urgency of their needs, expectations, or requirements; and the legitimacy of their involvement.

One main purpose of stakeholder analysis and presentation models is to prioritize stakeholders. For example, you can draw a variable against another variable and see where the stakeholders fit in that plot. If the variables are chosen carefully, the plot will suggest how much attention should be given to various stakeholders in the plot. As an example, Figure 8-2 presents such a plot in which the x-axis represents the level of interest from very low to very high and the y-axis represents the power/authority level from very low to very high. Stakeholders 1, 2, and 3 have a low interest in the project and low power, and therefore they do not deserve much of your time and effort. However, they must be monitored because their interest and power may change over time. At the other extreme, Stakeholders 8, 9, and 10 have a high interest in the project and have a very high capability to influence the project due to high power. These stakeholders should obviously be managed with maximum effort. Also, the high-authority/low-interest stakeholders should get due attention because they have the power to drive a change in the project.

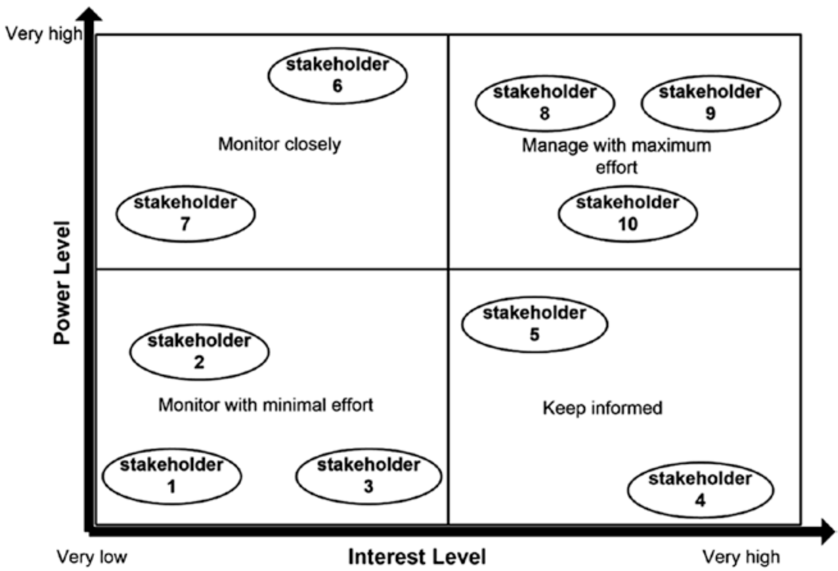

Figure 8-2. An example of determining strategy by plotting stakeholders against different variables

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Caution! Communication of information about the stakeholders is an important part of the stakeholder management strategy. For example, some of the information about certain stakeholders may be too sensitive to be included in a publicly shared document. As a project manager, you must exercise your discreet judgment on which information about which stakeholder to share with whom and to what detail.

The results of the information from stakeholder analysis and data presentation go into the *stakeholder register,* the main output of this process.

Output of Identifying Stakeholders

You store information about the stakeholders that you identified in a document called the *stakeholder register*. This information includes the following items:

- **Identification.** For example, name, location, organizational position, project role (if any), and contact information
- **Assessment.** Requirements and expectations coming from this stakeholder, the part or phase of the project that is of most interest to this stakeholder, and assessment of potential influence and impact on the project
- **Classification.** There will be a whole array of different kinds of project stakeholders with varied levels of influence. So, it's helpful to classify them in the register by using suitable criteria, such as whether they are internal or external to the performing organization; whether they are proponents or opponents of the project; their power, influence, impact, and interest levels; the direction of their influence; and so on.

In addition to this output, the Identify Stakeholders process may also generate change requests, and as a result some documents may need to be updated, such as those listed in the output column of Table 8-2.

STUDY CHECKPOINT 8.1

Knowing the Identify Stakeholders process, answer the following:

Q1. Describe which EEFs can influence the Identify Stakeholders process.

Q2. Describe which OPAs can influence the Identify Stakeholders process.

Congratulations, now you know the project stakeholders. But, before you can manage them, you need to plan. As pointed out earlier, managing stakeholders is all about stakeholders' engagement in the project. So, we want to plan stakeholder engagement.

Planning Stakeholder Engagement

Managing stakeholders is equivalent to managing their engagement in the project. So, the Plan Stakeholder Engagement process is all about developing a management strategy to keep stakeholders engaged in an effective way throughout the project. We have all the required information about the stakeholders, such as their needs, expectations, level of influence, and impact level, in the stakeholder register. Based on this, you develop approaches to interact with stakeholders effectively.

You use some tools and techniques with this information, along with the project management plan, to crank out the stakeholder management plan. The inputs, tools and techniques, and outputs of this process are shown in Table 8-3.

Table 8-3. The Plan Stakeholder Engagement Process: Inputs, Tools and Techniques, and Outputs

Input	Tools and Techniques	Output
1. Project charter 2. Project Management Plan: • Communications management plan • Resource management plan • Risk management plan. 3. Project documents: • Project schedule • Stakeholder register • Change log • Issues log • Assumptions log • Risk register 4. Agreements 5. Enterprise environmental factors 6. Organizational project assets	1. Data gathering: • Benchmarking 2. Data analysis: • Assumption and constraint analysis • Root-cause analysis 3. Data representation: • Mind mapping • Stakeholder engagement assignment matrix 4. Decision making: • Prioritizing/ranking 5. Expert judgment 6. Meetings	1. Stakeholder engagement plan

As the project proceeds, the memberships and needs and expectations may keep changing, and hence this plan may need to be changed accordingly several times by repeating the Plan Stakeholder Management process.

The first step to developing a stakeholder engagement plan is to get the raw data from the input items listed in Table 8-3.

Raw Data for Stakeholder Engagement Plan

From the input items for this project, you extract the information about the project and its stakeholders that would act as raw data. This data will help you develop approaches to involving stakeholders in the project, as shown in the following sections.

Information Project Level. From the project charter, fetch information about purpose, objectives, and success criteria of the project. Also, from the *project agreements* extract information on how to properly manage a stakeholder, including contractors, suppliers, and procurement groups.

Main Sources of Information About Stakeholders. *The stakeholder register* is the main source of information about stakeholders, such as their identity, needs, expectations, and so forth. Also, from the *project schedule*, extract information about the owner and executor of the project, and from the *resource management plan* get the information about the roles and responsibilities of stakeholders.

Secondary Sources of Information About Stakeholders. Assumptions about certain stakeholders can be found in the *assumptions log*, and risk owners and impactors can be found in the *risk register.* Information about stakeholders with issues and who may help to resolve them can be found in the *issues log*. As an example, one need of stakeholders with issues will be that you communicate with them. You can learn about stakeholders' attitudes toward and tolerance to risk from the *risk management plan*. From the *change log*, extract information about stakeholders who are sources of change requests and about those who will decide to accept, reject, or postpone a given request.

General Support Information for Stakeholder Management. As mentioned earlier, stakeholder management and communication management are tightly coupled. Communication strategies and their implementation from *communication management* would provide useful information for stakeholder management processes.

It's critical that you adapt stakeholder management to the project environment. That's where *enterprise environmental factors* play a role as input to this process. The organizational structure and culture in conjunction with political climate and stakeholders' risk tolerance can be used to select better options to effectively adapt stakeholder management to the project environment. Factors

like geographical distribution of facilities and resources and local and global culture and trends may also influence the development of an engagement plan.

The important *organizational process assets* in this process include the organizational policies and procedures about media, ethics, security, risk, communications, and so on.

For effective and efficient stakeholder management, it's important to learn from experience. Therefore, the lessons learned database and historical information are especially useful organizational process assets used as input for the Plan Stakeholder Management process.

You use the information discussed in this section as raw data for certain methods to develop the stakeholder engagement plan, as discussed in the next section.

Tools and Techniques to Develop Stakeholder Engagement Plan

To develop the stakeholder engagement plan, you do the following:

1. Analyze the raw data discussed in the previous section.
2. Compare the analysis results with benchmark.
3. Prioritize stakeholders and their needs.
4. Present the information in an easily useable form.

These steps are elaborated in the following.

Data Analysis. There are usually multiple possible strategies to apply to stakeholder engagement. These are tailored using *analysis of assumptions and constraints*, such as those about the stakeholders and their needs and expectations. Furthermore, you need to find the fundamental reason for the current level of support for or opposition to the project by a stakeholder so that you can chose appropriate strategies to bring the support or opposition to a desirable level. This fundamental reason is found by conducting a *root-cause analysis*.

Comparing Results. You can compare the results from data analysis with a suitable *benchmark*, such as results from a world-class project in the application area of your project.

Decision Making. You can prioritize stakeholders and their needs and requirements by using decision-making techniques such as prioritizing or ranking. Decision making has been explained and used in several chapters, such as Chapter 3.

Data Presentation. The data presentation involves presenting the information in an easily useable form. For example, *mind mapping* can be used to visually display information about stakeholders and how they are related to each other and to the organization. An important piece of information about stakeholders is stakeholder engagement, which is the heart of stakeholder management as it's critical to project success. You can define different levels of engagement for your project, such as those shown in Table 8-4.

Table 8-4. Levels of Stakeholder Engagement

Stakeholder Level of Engagement	Aware of Project and Potential Impacts	Action or Reaction
Leading	Yes	Actively working for project success
Supportive	Yes	Supporting the change to be caused by the impact
Resistant	Yes	Resisting the change to be caused by the impact
Neutral	Yes	Neither supportive nor resistant
Unaware	No	No intentional reaction to project

You should also always know what the current engagement level of a given stakeholder is and what level of engagement is required for that stakeholder should the project succeed. This information can be complied in the *stakeholders' engagement assessment matrix*, as shown in a simple example in Table 8-5, which compares each stakeholder's current engagement level with the desired one; *Current* indicates the current engagement and *Desired* indicates the desired engagement. The project team needs to identify the desired engagement level for the current phase of the project based on available information.

The example in Table 8-5 shows that stakeholder Janet is at the desired engagement level, while stakeholders Shanti, John, and City Mayor require further communications and additional actions to move them to the desired level of engagement.

Table 8-5. Stakeholders' Engagement Assessment Matrix

Stakeholder	Leading	Supportive	Resistant	Neutral	Unaware
Janet	Current, Desired				
Shanti		Desired		Current	
John		Desired			Current
City Mayor		Desired	Current		

The stakeholders' engagement assessment matrix exposes the gaps between the current and desired engagement levels. Accordingly, you can take action through the stakeholder management processes to fill these gaps.

In the process of doing analysis for engagement planning you will be holding *meetings* with the relevant stakeholders and seeking their *expert judgment* as needed on relevant topics, such as understanding and dealing with internal and external politics, culture, and power structures; appropriate communication means and strategies in different situations; and strategies for stakeholders' project engagement.

The output of this process is the *stakeholder management plan*, which contains strategies to implement and actions to perform to facilitate creative stakeholders' involvement in the project, such as making project decisions and executing the project.

The stakeholder management plan is implemented in the process of managing stakeholder engagement.

Managing Stakeholder Engagement

Managing stakeholder engagement means communicating and working with stakeholders to stay on the same page as them regarding the project requirements by addressing their needs, expectations, and issues as they arise. It is best done by getting them involved in project decision making and project execution at the appropriate level at the appropriate time. What do you really do when you manage stakeholder expectations? This is a three-pronged task:

Involvement for Confirmation. Involve the stakeholders in project decision making and project execution at the appropriate level at the appropriate time to ensure or confirm their continued project support.

Expectations Containment. Monitor and keep the expectations of the stakeholders within the project scope and project management plan through active communication, including negotiation.

Risk, Concerns, and Issues. Address stakeholder concerns, including those that may but have not yet become issues—for example, anticipate problems in the near future. Addressing such concerns may uncover some potential risks that will need to be addressed. An issue is an item or a matter that is under discussion or dispute, and there are most likely opposing views and disagreements about it among the stakeholders.

Understand, clarify, and resolve issues raised by the stakeholders. Some of the resolutions can give rise to change requests; other issues may be postponed to the next project or the next phase.

Caution! The importance of resolving issues in a timely fashion cannot be overstated. An unresolved issue can grow into a major source of conflict and a delay in the completion of project activities.

You can keep stakeholders on the same page as you by ensuring that they understand the internal dynamics and realities of the project, such as risks and interdependencies. Keeping them in touch with the project reality will increase the probability of project success. It's the responsibility of the project manager to manage stakeholder engagement by using the process presented in Table 8-6 in terms of input, tools and technique, and output.

Table 8-6. The Manage Stakeholder Engagement Process: Input, Tools and Techniques, and Output

Input	Tools and Techniques	Output
1. Project Management Plan: • Communications management plan • Stakeholder engagement plan • Risk management plan • Change management plan 2. Project documents: • Stakeholder register • Change log • Issues log • Lessons learned register 3. Enterprise environmental factors 4. Organizational project assets	1. Feedback 2. Interpersonal and team skills: • Conflict management • Negotiations • Observation/ conversation • Cultural and political awareness 3. Ground rules 4. Expert judgment 5. Meetings	1. Change requests 2. Project management updates: • Communications management plan • Stakeholders' engagement plan 3. Project document updates: • Stakeholder register • Change log • Issues log • Lessons learned register

Most of the items in the input and tools and techniques columns in Table 8-6 have already been discussed in this book. Some information regarding these items and relevant to this process will be discussed in this section.

Tip Managing stakeholders' expectations by engaging them is crucial for project success because it keeps their expectations in line with the project goals, objectives, and requirements as laid out in the project management plan. Otherwise, their definition of success will be different from your definition of success, and the project will fail in their eyes even if it succeeded according to the project management plan.

Earlier, I discussed how managing stakeholder engagement is a three-pronged task. That was the *what* of this process. But how do you perform this task? The *how* of the task also has three dimensions to it.

Manage Stakeholder Engagement According to a Strategy. This strategy and information on how to manage stakeholders' expectations by engaging them is found in the *stakeholder engagement plan*.

Identify the Right Stakeholders to Communicate With. A list of stakeholders and information about them is in the *stakeholder register*. Also, you can use the risk management plan to find out about risk categories, risk tolerance, and reporting format in the context of stakeholders. This is information that you will use to manage stakeholder engagement.

Communicate with the Stakeholders to Manage Their Project Engagement. Use the *communication management plan* as a guide for stakeholder communication regarding methods, technology, and format to use. While communicating to manage their expectations, you will be addressing their concerns and issues, for which you will need the *issues log* to document and track the status of those issues. Because it's a continuous process throughout the project, you will be regularly recording the lessons learned in the *lessons learned register* to subsequently use them to improve the process.

While addressing stakeholders' concerns and issues, you or they will be generating change requests, for which you will need a *change management plan* that describes the process for submitting, evaluating, and implementing the changes, and of course the *change log* to document and manage the change requests. The plans and other documents listed in the output columns of Table 8-6 are updated to reflect these changes.

As Table 8-6 shows, the *change requests* item is the main output of the Manage Stakeholder Engagement process.

Note Rarely does an issue grow to become a project or a project activity. It is your responsibility to resolve issues in a timely fashion in order to maintain a constructive relationship with stakeholders. However, the resolution may cause change requests for the small project, which should go through the proper evaluation and approval process before they are implemented, obviously.

Communication is the key to this process, and all the tools and techniques, listed is Table 8-6, used in managing stakeholder engagement are directly related to it. The feedback, negotiations, conflict management, observation and conversation, and ground rules (which are part of the team charter) were discussed in Chapter 6 in the context of obtaining resources and developing a project team, and observation and conversations were also discussed in Chapter 4. Cultural and political awareness is covered in the next chapter, on communication management.

STUDY CHECKPOINT 8.2

Knowing the Manage Stakeholder Engagement process, answer the following:

Q1. Describe which EEFs can influence the Manage Stakeholder Engagement process.

Q2. Describe which OPAs can influence the Manage Stakeholder Engagement process.

STUDY CHECKPOINT 8.3

True or False: A stakeholder is proposing something that is not within the planned scope of the project. The appropriate response to this proposal is to oppose it.

It is important to document your experience of managing stakeholder expectations, which includes causes of issues, how the issues were resolved, lessons learned, and so on. This will add to the organizational process assets and will be useful for upcoming projects and as a record through the lifecycle of the current project. As stakeholder engagement in the project needs to continue throughout the project lifetime, it needs to be monitored.

Monitoring Stakeholder Engagement

The Monitor Stakeholder Engagement process "supervises" stakeholder engagement to see how it's going. To keep it on track, information is distributed among the stakeholders and the engagement strategies and plans are modified. Like a typical monitoring and controlling process, its main input is work performance data and main output the work performance information. Table 8-7 presents the Monitor Stakeholder Engagement process in terms of the input, tools and techniques, and output.

Table 8-7. The Monitor Stakeholder Engagement Process: Input, Tools and Techniques, and Output

Input	Tools and Techniques	Output
1. Project Management Plan: • Communications management plan • Stakeholder engagement plan • Resource management plan 2. Project documents: • Stakeholder register • Project communications • Issues log • Risk register • Lessons learned register 3. Work performance data 4. Enterprise environmental factors 5. Organizational project assets	1. Data analysis: • Stakeholder analysis • Root-cause analysis • Alternatives analysis 2. Decision making: • Multicriteria decision analysis • Voting 3. Data reorientation: • Stakeholders' engagement assessment matrix 4. Communication skills: • Feedback • Presentation 5. Interpersonal and team skills: • Leadership • Networking • Active listening • Cultural and political awareness 6. Meetings	1. Work performance information 2. Change requests 3. Project management updates: • Communications management plan • Resource management plan • Stakeholder engagement plan 4. Project document updates: • Stakeholder register • Risk register • Issues log • Lessons learned register

The core of performing the Monitor Stakeholder Engagement process is described in the following section.

Performing the Monitor Stakeholder Management Process

Monitoring stakeholder engagement using items from the input and tools and techniques columns of Table 8-7 is described in the following steps.

Get the Project Execution Data and Results. The input item *work performance data* from project execution includes the status of stakeholder engagement in the project, such as who is supporting or opposing the project and at what level. The other input item *project communication* contains the

project works performance report and any information that will be or has been distributed to stakeholders.

Communicate. Distribute the information in *project communications* that needs to be distributed according to the *communication management plan* using communication methods like *presentation*. Make sure the information has been received and understood using communication methods like *feedback*.

Analyze Work Performance Data. Analyze the stakeholder engagement data in the *work performance data* document using data-analysis techniques such as stakeholder analysis, root-cause analysis, and alternatives analysis. The *stakeholder analysis*, already described in this chapter, is performed to determine the support or opposition of stakeholders regarding the project. The *root-cause analysis*, discussed in an upcoming chapter on quality management, is performed to determine the fundamental reason for not achieving the engagement as planned. Once the root causes are discovered, the *alternatives analysis*, discussed already in multiple chapters, is performed to explore and evaluate the various options for responding to the failure to engage as planned.

Make Decision. After conducting the alternatives analysis, evaluate the various options; make a decision as to which option to choose by using multicriteria decision analysis or by voting, both discussed in Chapter 3.

Generating the Output. The data analysis generates the output item *work performance information*, which contains the current stakeholder engagement status, such as project support level compared to desired level as defined in the *stakeholders' engagement assessment matrix*. The decision on which response option to choose generates change requests, whose implementation causes plan and project document updates, as listed in the output columns of Table 8-7.

You will also make use of *interpersonal and team skills* in monitoring stakeholder engagement. For example, you will use leadership skills, covered in Chapter 2, to share your project vision with the stakeholders and motivate them to support the project objectives and outcome; networking to find out the project support level among stakeholders; active listening, covered in Chapters 2 and 9, to minimize misunderstandings and to build consensus; cultural awareness, covered in Chapter 9, to consider cultural sensitivity and differences in communication and engagement requirements; and political awareness, covered in Chapter 9, to better understand organizational strategies and power structures and to communicate accordingly in order to maximize project support.

The enterprise environmental factors and organizational project assets that influence are pretty much the same as in the Manage Stakeholder Engagement process. Other items from the input column not mentioned here have their usual roles to play and were already discussed in this chapter.

STUDY CHECKPOINT 8.4

Knowing the Monitor Stakeholder Engagement process, answer the following:

Q1. How will the stakeholder register and risk register be updated as a result of this process?

Q2. How will the stakeholder engagement plan, communications management plan, and resource management plan be updated as a result of this process?

The three most important takeaways from this chapter are the following:

- Stakeholder management is about managing the engagement of stakeholders in the project and monitoring that engagement.
- The engagement is done by getting stakeholders involved in project decision making and project execution at the appropriate level at the appropriate time.
- The ultimate purpose of engagement is to maximize support for the project, and it's achieved by managing stakeholders' needs and expectations and addressing their concerns.

Summary

It is crucial for the success of the project to get the support of stakeholders, which is best done by getting them engaged in the project at the appropriate level at the appropriate time. Project stakeholder management is all about stakeholder engagement, of which the big part is managing stakeholder needs, expectations, and concerns.

In stakeholder management, you first identify stakeholders using project business documents and other items as input to produce the stakeholder register; you generate a stakeholder engagement plan by using the project charter and other items as input. Because the processes of generating the stakeholder register and stakeholder engagement plan are performed throughout the project, the stakeholder register can be and is used as an input to the process of creating the stakeholder engagement plan, and the stakeholder engagement plan can be and is used as an input to the process of generating the stakeholder register, as shown in Figure 8-1.

You manage and monitor stakeholder engagement according to the stakeholder engagement plan. The monitor engagement process takes the

engagement-related data from the project's execution and converts it into work performance information, then generates necessary change requests.

Road Ahead. The communication management plan is an input to all the stakeholder management processes, underlining the close connection between stakeholder management and communication management, which will be discussed in the next chapter.

Exam's Eye View

Comprehend

- Managing stakeholders includes identifying stakeholders, planning stakeholder engagement, and managing and controlling stakeholder engagement.
- The stakeholder management plan contains strategies to implement and actions to perform to facilitate creative stakeholders' involvement in the project, such as making project decisions and project execution.
- The main purpose of managing stakeholder engagement is to get continued project support from stakeholders. It done by managing their needs and expectations through their involvement in the project.
- The Monitor Engagement process oversees stakeholder engagement and converts the engagement-related data from the project's execution into work performance information, then generates necessary change requests.

Look Out

- Managing stakeholder expectations is crucial to the success of the project by keeping these expectations in line with the project management plan.
- After the stakeholders have been identified, stakeholder management is all about managing and controlling stakeholder engagement.
- A key purpose of the stakeholder engagement plan is to support interactions with project stakeholders to serve the project's interest.
- The communication management plan is an input to all the stakeholder management processes.
- Unresolved issues can grow to become a source of conflict.

Memorize

- The *stakeholders' engagement assessment matrix* is a table that compares individual stakeholders' current engagement level with the desired one.
- Stakeholder management is not about managing or controlling the stakeholders; it is about managing or controlling their engagement with the project.
- Mind mapping is a technique used to visually display information about stakeholders and how they are related to each other and to the organization.

Review Questions

1. The data presentation model that presents a stakeholder's influence, impact, and interest in one plot is called a:

   A. Salience model

   B. Stakeholder cube

   C. Influence/impact/interest grid

   D. Three-dimensional model

2. You are project manager of project named "Teach the Congress." Your friend Cosmo is a project manager of a project that shares some resources with your project. What kind of influence does Cosmo have on your project?

   A. Upward

   B. Outward

   C. Sideward

   D. Downward

3. You have just joined a project that has already been planned. You want to take a look at strategies to implement and actions to perform to facilitate creative stakeholders' involvement in the project, such as making project decisions and doing project execution. Where you will look?

   A. Stakeholders' engagement assessment matrix

   B. Mind mapping

   C. The stakeholder engagement plan

   D. Project stakeholder register

4. Which of the following is not generated during the Plan Stakeholder Engagement process?

   A. Stakeholder register

   B. Stakeholder engagement plan

   C. Stakeholders' engagement assessment matrix

   D. Strategies about stakeholders' involvement

5. The focus of the stakeholder management knowledge area is:

   A. Stakeholder management

   B. Managing stakeholder expectations

   C. Controlling stakeholders

   D. Stakeholder engagement

6. Project business documents are input to which stakeholder process?

   A. Identify Stakeholders

   B. Manage Stakeholder Expectations

   C. Plan Stakeholder Engagement

   D. Monitor Stakeholder Engagement

7. Which of the following is an input to all the processes of stakeholder management?

   A. Project charter

   B. Communications management plan

   C. Resource management plan

   D. Stakeholder engagement plan

8. Which of the following is not an output of monitoring stakeholder engagement?

   A. Performance reports

   B. Change requests

   C. Issues resolved

   D. Stakeholder engagement plan changed

9. You have generated a project document named *project communications* that can be used in which of the following processes?

   A. Manage Stakeholder Engagement

   B. Monitor Stakeholder Engagement

   C. Plan Stakeholder Engagement

   D. Distribute Information

10. The salience model can be used in which of the following processes?

    A. Manage Stakeholder Engagement

    B. Monitor Stakeholder Engagement

    C. Plan Stakeholder Engagement

    D. Identify Stakeholders

CHAPTER

9

Project Communication Management

The objectives covered in this chapter make up 10 percent of the exam, equivalent to about 11 questions. Study the whole chapter in detail.

It's enough to just remember the name of the input, tools and techniques, and outputs. You should know what is in a given input item that the given process uses and how it helps generate the output, as well as what a given tool or technique does in a given process.

You should understand very well the concepts and methods of the stakeholders' engagement assignment matrix, interpersonal and team skills, and communication methods and models.

While studying this knowledge area and its processes, pay attention to how the tasks can be adapted to various needs, and recognize an agile environment in action; e.g.; continual assessment generates change requests, which lead to changing plans—i.e., adapting.

P. Sanghera, *CAPM® in Depth*, https://doi.org/10.1007/978-1-4842-3664-2_9

CAPM Exam Objectives

Project Communication Management:

1. Understand the three project management processes in the project communication management knowledge area.
2. Identify the input, tools and techniques, and outputs defined in the three project communication management processes.
3. Identify key concepts and approaches in project communication management, including tailoring and special considerations for agile/adaptive environments.
4. Recognize the dimensions of communication and components of a communications management plan.
5. Identify communications skills and methods for project communication management.

Communication skills are critical for success not only in management, including project management, but also in a multitude of short-term and long-term tasks we perform each day. These skills can be applied to all communication techniques, such as verbal, written, video, and body language, as well as to listening. They are also an important component of other skills required for effective project management, such as negotiating, influencing, and leadership, and are one of the three skills that constitute the PMI's talent triangle for project management. Other common usages for communication skills are performing tasks such as fact finding to develop or verify information; probing or analyzing an idea or situation; holding meetings and conducting discussions; setting and managing expectations; resolving conflicts; and educating, coaching, motivating, pursuing, or reassuring a person or a group. You manage project communication using processes in the knowledge area called project communication management.

In project management, with whom do you largely communicate using your communication skills? The answer is project stakeholders. This shows how intimately connected the communication management and stakeholder management project management knowledge areas are. The central question in this chapter is: how do you use communication for the success of the project? In search of an answer, we will explore three avenues: plan communication, manage communication, and monitor communication.

Managing Project Communication: Big Picture

There is a common thread that runs through almost all activities and processes in project management, and that is communication. The project and its activities would fail without effective communication. Communication is an exchange of information among persons and groups by using an effectively common

system of signs, symbols, and behavior. I use the term *effectively common* to take into account the fact that even if two communicating entities are using two different systems, the "translators" between the communicating entities produce the results as if the two entities were using a common system. For example, I might be using a Windows computer, and you might be using a Macintosh, but we can exchange e-mails without having to deal with the differences between the two machines.

Tip Communication is a common thread that runs through almost all activities and processes in project management. You manage communication using processes in the communication management knowledge area, but communication itself permeates through almost each project activity.

The importance of communication in project management cannot be overemphasized. Even a well-scheduled and well-funded project can fail in the hands of a hardworking team of experts because of the lack of proper and timely communication. As a project manager, you may be dealing with a wide functional variety of individuals, ranging from executives to marketing personnel, sales folks, and technologists. You should be able to wear different communication hats depending upon with whom you are communicating. For example, you will not be talking in terms of technical jargon with executives or marketing folks, and you will not speak marketing lingo to software developers. You will be speaking to different stakeholders in their "language" while filling the "language gap" between different functional groups and eliminating misunderstandings resulting from miscommunication. The key point is that you put on the appropriate communication hat depending on which individual or group you are communicating with. Be able to switch communication hats quickly and avoid technical jargon and acronyms that are not understood by the person or the group you are communicating with. The goal is clarity of language to convey the message accurately.

In a project, you will be communicating with project stakeholders. The intrinsic connection between communication management and stakeholder management is illustrated in Figure 9-1, with communication management processes in gray and stakeholder management in white.

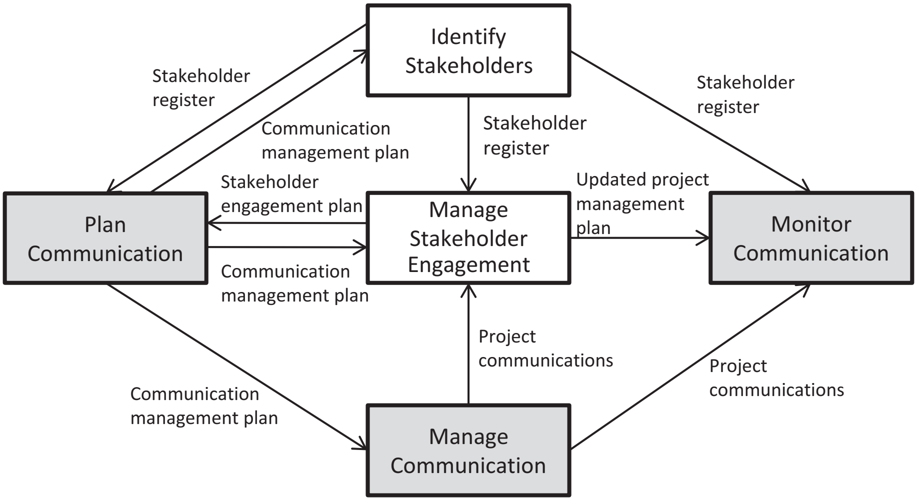

Figure 9-1. Big picture of project communication management

As shown in Table 9-1, project communication management is constituted by the following three processes:

- **Plan Communication.** This is the process of determining the information needs and accordingly developing the project communication plan to meet those needs.
- **Manage Communication.** This is the process of managing the distribution of relevant information to the right stakeholders at the right time using the right methods. This managing of information covers the creating, collecting, storing, retrieving, and distributing of needed project information.
- **Monitor Communication.** This is the process that oversees communication to make sure that the information needs of stakeholders are being adequately met throughout the project as planned, and that this communication is producing the desired impact.

Tip The major goal of communication management is to deliver the right information to the right stakeholders at the right time using the right methods to produce the desired impact.

These processes are mapped to their process groups in Table 9-1.

Table 9-1. Processes of Project Communication Management Mapped to the Process Groups of Major Outputs

Resource Management Process	Process Group	Major Output	Performed
Plan Communication	Planning	Communication management plan	Throughout the project
Manage Communication	Executing	Project communications	Throughout the project
Monitor Communication	Monitoring and Controlling	Work performance information Change requests	Throughout the project

In a nutshell, communication in project management has much to do with managing the information and delivering it to project stakeholders at the right time by using the appropriate methods. The project stakeholders were already identified in the initiation stage, so we can plan project communication for them.

Planning Project Communication

First, you should realize that the communication activities may be performed in many possible forms, such as from body language to word of mouth or a written formal document; from with your peers to up and down the organizational hierarchy, to the media; and from unofficial to official. You should be conscious about using an appropriate form of communication depending on the nature of the communication task at hand and who you are communicating with.

In a project environment, *communication* means communicating with the project stakeholders. Plan Communication is the process of determining the information needs of the project stakeholders, which in general will be different for different stakeholders, and accordingly designing the communication approach within the constraints of the available organizational assets at your disposal to meet those needs.

To be specific, communication planning determines the following:

- The communication and information needs of each project stakeholder—individual or group
- The few Ws: what information is needed and where it will be stored, when it is needed, who needs it, and who will deliver it, who can access it, and so on
- How the information will be delivered—for example, by e-mail, phone call, or presentation
- Gap factors: time zone differences, language barriers, and cross-cultural barriers

Caution! Planning communication is the process of determining the information needs of each project stakeholder and accordingly the communication approach. Poor planning will produce undesired results, such as the wrong individuals getting sensitive information, necessary information not getting to the right stakeholders in time, wrong communication methods being used, and so on.

As mentioned in the last chapter, the stakeholder register is developed during the Identify Stakeholders process, which, along with the project plan, is the major input into the Plan Communication process presented in Table 9-2 in terms of its inputs, tools and techniques, and outputs. Also, because communication is the common thread running through the whole project, and because it must be adapted to the whole project environment, all the enterprise environmental factors and all the organizational process assets should be considered as input. Historical information and lessons learned are particularly important because they can be used for wisely planning the communication based on experience.

Table 9-2. The Plan Communications Management Process: Inputs, Tools and Techniques, and Outputs

Input	Tools & Techniques	Output
1. Project charter 2. Project Management Plan: • Resource management plan • Stakeholder engagement plan 3. Project documents: • Requirement documentation • Stakeholder register 4. Enterprise environmental factors 5. Organizational project assets	1. Communication requirement analysis 2. Communication technology determination 3. Communication methods and models determination 4. Interpersonal and team skills: • Communication style assessment • Cultural and political awareness 5. Data representation: • Stakeholders' engagement assignment matrix 6. Expert judgment 7. Meetings	1. Communications management plan 2. Project management updates: • Stakeholder engagement plan 3. Project document updates: • Project schedule • Stakeholder register

Performing the Plan Communication Management Process

The core of planning communication management can be expressed in the following steps in terms of the inputs, tools and techniques, and outputs listed in Table 9-1:

1. From the *resource management plan*, get relevant "how-to" information about resources, such as team members, other stakeholders, and communication resources, and how they are categorized, allocated, managed, and released. This info may help in determining stakeholder communication needs and how to fulfill them.
2. From the *stakeholder engagement plan*, learn about the stakeholder engagement strategies, which would need communication to be implemented.
3. Find out about stakeholders from the *stakeholder register* and *project charter*, which identify the key stakeholders and possibly their responsibilities.
4. Fetch stakeholders' communication requirements from *requirement documentation*, if any.
5. Determine the stakeholders' communication needs by performing the *communication requirement analysis* on the information or on raw data collected in the preceding steps.
6. Determine the *communication technology* to use to store and deliver the information.
7. Determine the *communication methods and models* to communicate with.
8. Determine the interpersonal and team skills data-presentation techniques to be used in communication.
9. Document all these determinations and "how-to's" in the *communications management plan.*
10. Update the documents that need to be updated as a result of this process, such as those listed in the output column of Table 9-2.

The tools and methods just mentioned are explained in the following section.

Tools and Techniques for Communication Planning

Recall that communication is the transferral of information from one point to another. It expends resources. To optimize the use of resources and the benefits of communication, you need to analyze the communication requirements and determine the best communication technology to be used to facilitate information transfer. These and other relevant tools and techniques are discussed in the following sections.

Communication Requirements Analysis

Communication requirements needed for the communication planning process must be analyzed. This analysis will generate the communication needs of the project stakeholders. For example, a communication requirement may specify the type of information needed and the format in which this information should be delivered. The analysis of this requirement will estimate its value—for example, fulfilment of this requirement will significantly contribute to the success of the project, or the lack of it will result in the failure of the project or one of its components. So, one of the purposes of communication requirements analysis is to optimize the use of resources in communication by prioritizing requirements.

Tip Communication requirements need to be analyzed to determine the communication needs of the project stakeholders. This is important for optimal use of the communication resources and for project success.

The following are some examples of what types of information and sources of communication requirements you will need to analyze for your project:

- **Input Documents.** Type of information and sources of communication requirements mentioned in the previous section.
- **Relationships.** Organizational and stakeholder responsibility relationships. *Organizational charts* can be helpful to figure out some of this information.
- **Groups.** Different groups, disciplines, departments, and specialties involved in this project—for example, marketing, sales, and engineering as departments and software engineering and testing as groups in the engineering department— and their interdependencies.

- **Logistics.** How many individuals and groups will be involved in the project and where they are located. Obviously, this information is necessary to plan communication.
- **Information Needs.** Communication is performed to deliver or exchange some kind of information. So, to plan communication effectively, it's important to know the following information needs:
    - Information needs of the stakeholders
    - Internal information needs—for example, communication across the performing organization and communication within the project team
    - External information needs—for example, communicating with contractors, media, and the public
    - Legal requirements, such as privacy of certain types of information
    - Number of communication channels or paths in different modes, such as one-to-one, one-to-many, and many-to-many.

You can appreciate the complexity of communication by realizing that there are $n(n\text{–}1)/2$ possible communication channels among n stakeholders in many-to-many mode. You can derive this formula by noting that each of n individuals can communicate with n–1 other individuals. If we multiply n by n–1, we are double counting each channel, and hence we divide by 2. For example, if there are 20 stakeholders, the possible number of communication channels is 20 (20-1)/2=190.

Caution! Note that PMI lists communication technology, communication models, and communication methods as tools and techniques in the Plan Communication Management process. Generally, we use the tools and techniques listed in a process to run the process. But, in this case, we are determining, not necessarily using, the communication technology, models, and methods that will be needed to facilitate communication among stakeholders.

Based on the communication needs, you can determine which communication technology, communication models, and communication methods will be appropriate to meet these needs.

Communication Technology Determination

Depending on communication needs and the nature of the information, the communication technology used may vary from a conversation in a hallway, to meetings, to a sophisticated information system. The following factors can contribute to determining the communication technology to be used for your project:

- **Availability.** If you are considering a number of options, obviously the technology that's already in place is more likely to be chosen.
- **Project Environment.** The project environment can also affect the choice of communication technology. For example, the communication technology requirements for a project team that meets face-to-face will be different than those for a virtual team.
- **Project Length.** The length of the project affects communication technology requirements in the following ways:
    - Is it worth it to spend on a technology for the given length of the project?
    - Will the technology under consideration change during the course of the project?
    - If yes, that will mean extra costs for the new technology and for training team members to use it.
- **Urgency of the Information Need.** How frequently the information needs to be updated will also play a role in determining the communication technology. For example, information that does not need to change frequently can be delivered in written reports, whereas information that can change very frequently can be delivered through web pages.
- **Staffing Preparation Level.** Another factor that can be considered in making the communication technology decision is the users' (project team and other stakeholders) level of preparation for using a given technology. Are the users already fluent in this technology, or will they need to be trained? Training and learning for the project staff could be valid issues on the table.
- **Confidentiality of Information**. This will also influence what technology you can use.

- **Organizational Policy on the Use of Social Media**. This will affect what information you can put on social media.

Communication Models and Methods Determination

If you have some experience in IT or in the field of communication, be aware that when PMI refers to communication models and methods, it has very specific things in mind. Although it's a very broad topic, we will confine our discussion to what PMI means by communication models and methods for the purpose of the exam.

Communication Models. A general illustration of PMI's communication model is seen in Figure 9-2, and the different components in the communication path are explained in the following list:

- **Sender.** The individual that initiates the communication by sending the original message.
- **Message.** An encoded piece of information that travels from one individual to another.
- **Encode.** To convert thoughts into a format that can be sent as a message to the receiver.
- **Decode.** To convert the encoded message back into thoughts and ideas upon which one could act.
- **Medium.** The means of communication used to send and receive the message. E-mail, telephone, and face-to-face conversation are some examples of media.
- **Feedback Message.** The response sent by the receiver to the sender. It may be a simple acknowledgment, or it may be a full message that may require a response.
- **Receiver.** The individual that receives the original message sent by the sender
- **Noise.** While the message travels through the medium, it can be interrupted and modified by some interfering entity called *noise*. Anything that interferes with the transmission and understanding of the message is called noise. Some examples are distance, lack of background information or context in which the message is composed, and unfamiliar technology being used. For example, e-mailing and texting have their own lingo, acronyms, and symbols that can become noise for people who are new to these technologies.

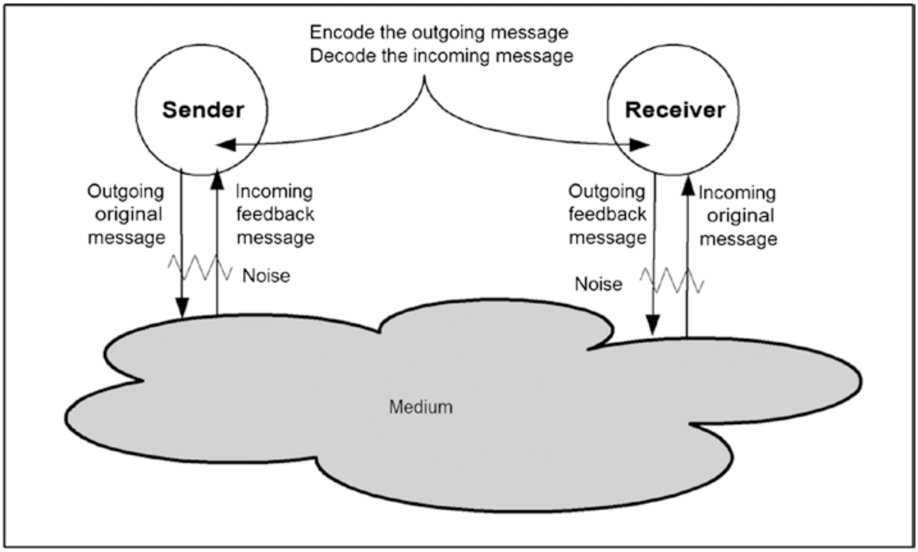

Figure 9-2. A general illustration of a communication model as viewed by PMI

The communication model presented in Figure 9-2 is very general, out of which we can slice out PMI's modes, as shown here:

1. Eliminate the feedback message and any consideration of noise from Figure 9-2 and you have got PMI's *basic sender/receiver model* of communication. In this model, message can be sent, but it does not ensure that the message was understood by the receiver because there is no feedback.
2. To the basic sender/receiver model, add the feedback message and noise consideration due to physical sources, such as technology or infrastructure, and you have got the *basic interactive model*. It can be used to send a message with some assurance that the message is understood.
3. To the basic interactive model, add human factors such as culture differences to the sources of noise, and you have got *more complex interactive model*, as presented in Figure 9-2. It can be used to send a message with assurance that the message is understood.

For the communication to work, both the senders and the receivers have some responsibilities. The responsibilities of the sender include ensuring that the message being sent conveys the complete information clearly and ensuring that the information is received correctly and understood properly by the receiver. The responsibilities of the receiver include ensuring that the information is received correctly and understood properly in its entirety and that it is acknowledged.

STUDY CHECKPOINT 9.1

Saira Bano is the project manager for the Sequence the DNA of a Buffalo (SDB) project. Match each item in the first column of the following table to the correct item in the second column.

Term	Action
A. Message	1. While developing the schedule, Saira realized that there was a risk involved in the project. So, she put her thoughts into a note that she wrote on her computer.
B. Medium	2. She sent the note to the project sponsor.
C. Encode	3. She used e-mail to send the message.
D. Noise	4. The sponsor received the message.
E. Receiver	5. The sponsor could not understand some of the acronyms and terms in the e-mail message, such as variable number of tandem repeats (VNTR, central dogma of molecular biology).
F. Feedback	6. The sponsor responded to Saira, expressing his concern that he could not exactly understand her concerns.

Communication Methods. In its most basic form, communication is an exchange of information between two entities. Even communication among several entities is better handled by looking at it as a set of exchanges between two entities. For example, A communicating with B, C, and D is a set of exchanges between A and B, A and C, and A and D. In other words, exchange between two entities is the basic building block of communication. So, we can always break down a communication as an exchange between a sender and a receiver.

From the perspective of how the sender and the receiver are involved with each other through the communication system, communication can be classified into the following two main categories:

1. **Interactive Communication.** In this type of communication, the receiver receives the message and sends a response to it. This way, the communicating entities keep switching the roles of sender and receiver. There are two kinds of interactive communication:

   - **Asynchronous Communication.** A communication in which the two communicating entities do not have to be present at each end of the communication line at the same time. E-mail is an

example of asynchronous communication because when the sender of the e-mail pushes the Send button, the intended recipient of the e-mail message does not have to be logged on to the e-mail server. The recipient can log on later, retrieve the message, and read it.

- **Synchronous Communication.** A communication in which the two communicating entities have to be present at each end of the communication line at the same time. It's a live, real-time communication—if you are not present when the sender is sending the message, you miss the message. Speaking with someone face-to-face and conversing with someone on the phone are two examples of synchronous communication.

2. **One-way Communication.** There are two kinds of one-way communication:
   - **Pull Communication.** Pull communication is used when it's up to the receivers to determine if and when they need the information. In this kind of communication, the receiver pulls the information from a pool of information. Downloading from websites is an example of this type of communication.
   - **Push Communication.** In this kind of communication, the sender broadcasts the information to a set of entities without waiting for the request of information and without the need to confirm that the information reached its destination. Marketing e-mails and letters are examples of push communication. Status reports are another example of push communication.

The pull and push methods can also be used in conjunction with each other. For example, the sender can also push the information to a pool, and the receivers can pull it from there at their own convenience.

The communication types discussed here are called *communication methods* in the PMI Standard. Depending on the purpose, the project manager can decide which of these communication methods to use. Quite often a hybrid approach is used in the real world—that is, a mix of more than one method.

Note *Communication approaches*, to be determined for the communication plan, refers to the setting or environment in which the information flows, such as *interpersonal communication* (e.g.; face-to-face conversation); *small group communication* (many-to-many; e.g.; a meeting); *public communication* (one-to-many; e.g.; one speaker addressing a gathering); *mass communication* (one-to-many; e.g.; broadcast or as press release); and network computing technology (e.g.; online social networking sites).

Interpersonal and Team Skills. Interpersonal and team skills, including the following, can be used when dealing with different aspects of communication.

Political awareness. Political awareness refers to recognizing and understanding the power structure of the organization and the influence of this structure on the relationships such as inner-management and team manager to team member relationships. This technique determines the proper communication approaches and strategies to operate within this power structure by integrating political awareness into the project environment.

Cultural awareness. Culture awareness refers to recognizing and understanding the cultural differences among stakeholders. This technique determines the proper communication approaches and strategies to operate within the framework of cultural differences and sensitivity. This will help you avoid misunderstandings and resulting conflicts caused by poor training regarding cultural differences and cultural insensibilities.

Communication-style assessment. This technique refers to identifying proper content presentation and format and preferred delivery method for a planned communication activity. This is often used for unsupportive stakeholders to fill the gap between their current support position and the desired one, as recorded in the *stakeholders' engagement assignment matrix*.

To close this gap between current project support position and the desired one, the *engagement assignment matrix* can be re-analyzed to modify or identify new communication requirements.

Of course, in the process of making these determinations, you will need to hold meetings with the project team and other stakeholders about communicating and other matters. You can also seek an expert on communication-related topics.

The result of the activities described in this and the previous section is the generation of the project communication plan.

Project Communication Plan

The major output of communication planning is the communication management plan. This is the document that describes the communication expectations and needs, as well as the plans for how these needs will be met. It includes the following:

- Communication requirements of the project stakeholders
- Information to be communicated: content, format, and level of detail
- Who will communicate the information, who will receive it, and why
- The person responsible for authorizing the release of confidential information
- Methods of communication that will be used, such as e-mail, presentation, and press release
- The frequency of communication, such as daily or weekly
- The method and procedure for escalating those issues that cannot be resolved at a lower staff level, such as project level
- A glossary of common communication terminology
- Methods and procedures for updating and refining the communication management plan if needed as the program progresses
- Communication constraints

When executing a project in this Information Age, more likely than not you will need multiple technologies for communication, such as e-mail, web calendars, and video conferencing. Therefore, it is important that you plan for the communication technology requirements. This planning has two components: the tools that are needed and the usage of those tools. To determine which tools are needed, ask questions such as the following:

- How frequently do you need to update the information?
- Will the team hold face-to-face or virtual meetings?

For information that does not change often, written reports will be sufficient, whereas information that needs to be updated frequently and on a moment's notice needs web communication tools. To plan effective usage of the tools, ask the following questions:

- Are the tools (communication systems) already in place and ready to be used?

- Will the available communication tools change before the program ends?
- Are the team members familiar with the tools or do they need training to use them?

Also, there will be a method and procedure of how to modify the plan, if need be.

Updates to Project Documents

During communication planning, you might realize that you need to make some changes in the project schedule and stakeholder register. Accordingly, you will need to change these documents.

■ **Tip** While planning for communication (or doing anything, for that matter), pay attention to details, ask questions, and probe the situation to come to a better understanding. A well-understood problem is already half-solved. Be an active and effective listener.

Part of managing stakeholders' expectations is to keep them on the same page as you. To stay on the same page with the stakeholders, it's important to distribute the relevant information at the right time.

STUDY CHECKPOINT 9.2

Knowing the Plan Communication Management process, answer the following:

Q1. Describe which EEFs can influence this process.

Q2. Describe which OPAs can influence this process.

Q3. Describe how the documents listed in the output column of Figure 9-2 will be updated.

With the communication plan in our hands, we are ready to make communication happen—e.g.; implement the plan by managing and monitoring communications.

Manage Communication

Throughout the project lifecycle, you need to continually distribute the relevant information to the right stakeholders at the right time by using appropriate methods. A more complete statement would be that you need to make communications happen, where the happening of communications includes creating, collecting, storing, retrieving, and, at the end, disposing of project information. The process to make it happen is called Manage Communication, and it is run in accordance with the communication management plan. This process is presented in Table 9-3 in terms of input, tools and techniques, and output.

Table 9-3. The Manage Communication Process: Input, Tools and Techniques, and Output

Input	Tools and Techniques	Output
1. Project Management Plan: • Communication management plan • Stakeholder engagement plan • Resource management plan 2. Project documents: • Stakeholder register • Quality report • Risk report • Issues log • Change log • Lessons learned register 3. Work performance reports 4. Enterprise environmental factors 5. Organizational project assets	1. Communication technology 2. Communication methods 3. Communication skills: • Feedback • Presentation • Nonverbal • Communication competence 4. Project reporting 5. Interpersonal and team skills: • Conflict management • Meeting management • Networking • Active listening • Cultural and political awareness 6. Information management systems 7. Meetings	1. Project communications 2. Project management updates: • Communication management plan • Stakeholder engagement plan 3. Project document updates: • Stakeholder register • Project schedule • Risk register • Issues log • Lessons learned register 4. Organizational project assets update

Overall, the Manage Communication process is run according to the *communication management plan*. The core task of this process is to distribute the right information to the right stakeholder at the right time. All other activities in this process are dedicated to this core task. You get information about stakeholders, such as their identity and communication needs, from

the *stakeholder register*; find out from the *resource management plan* what communication is needed for the management of team and physical resources; and also learn communication strategies from the *stakeholder engagement plan* to keep stakeholders engaged in the project.

With this knowledge at hand, distribute the information using communication technology, methods, and skills.

What Information to Distribute and in What Form?

Not all the stakeholders need the name kind of information. That said, in this section we discuss, in general, what kinds of information is distributed, where it is obtained from, and in what form it is distributed.

Information sources are the input documents discussed next.

Quality and Risk Reports. Quality-related information, such as quality issues and improvements made in project processes, is collected from the *quality report*, an output of the Manage Quality process. Risk-related information, such as project-level and individual risks and their summaries, can be fetched from the *risk report*, an output of the Identify Risks process.

Work Performance Reports. These reports are an output of the Monitor and Control Project Work process and are discussed in Chapter 3. Status reports and progress reports are two common examples of work performance reports.

You take needed information and distribute it among the relevant stakeholders, an act that is called in PMBOK by the name *project reporting*.

Performance Reporting. Performance reporting refers to collecting and distributing work performance information, which includes standard reports generated by various processes as just discussed, such as work performance reports and ad hoc reports and presentations prepared during this process. The information could be in various formats, from an informal chat to a formal report, have various levels of detail, be at different project levels, and come with different frequencies, from periodically to "on an exceptional basis." These variations arise from the different information needs of different stakeholders. For example, on a periodic basis, an analysis of the baseline compared with actual work data yields performance and forecasts the project results, which can then be communicated in appropriate detail to meet the need of a group of stakeholders.

As mentioned earlier, presentation is one form of performance reporting.

Presentation. Listed in Table 9-3, presentation is, according to PMBOK, a communication skill. Certainly, you need good communication skills to prepare and deliver a presentation. Based on stakeholders needs, it could be on a wide

variety of topics, such as progress reports, information updates, and any project documents. To make an effective presentation, you should always consider the audience and their needs, and use audio/visual and other appropriate tools, such as tables, graphs, and histograms. Essential elements such as background information and conclusions should be included. It's important watch your nonverbal communication, such as body language, during your presentation.

Note The EEFs and OPAs that influence this process are the same as those in planning communication; see Study Checkpoint 9.1.

In addition to the two tools—performance reporting and presentation—just discussed, you will need other tools to manage communication, such as communication technology and methods and communication skills.

Tools and Techniques for Managing Communication

To manage communication, you will also use the two tools discussed in the following sections.

Communication Technology and Project Management Information Systems (PMIS)

Communication technology is discussed in the planning communication section in this chapter, and PMIS is covered in multiple chapters, such as 3 and 5. Recall that an information management system refers to a set of standard tools that a project manager can use to capture, store, and distribute information to stakeholders about various aspects of the project, such as project costs, project schedule, schedule progress, and performance. Depending upon the stakeholders and the kind of project information to be distributed, a variety of information management tools can be used.

Hard-copy document management: reports, letters, and memos

Electronic and Web communications management: press releases, e-mail, fax, voice mail, telephone, video and web conferencing, websites, and web publishing

Web project management tools, including social media: web interfaces to scheduling and project management software, meeting and virtual office support software, portals, blogs, and collaborative work management tools

Examples of distribution formats supported by information management systems may include tables, spreadsheet analysis, and presentations. You can use the capabilities and features of the applications, such as graphics, to make the information easy to understand and hence enhance its impact.

Communication Skills

You will need a wide variety of communication skills to manage communication. Out of those listed in Table 9-3, we have already discussed *presentations,* and *feedback* was discussed in Chapter 6, which occurs in response to any communication, deliverable, or situation in the context of project communication. Feedback is happening in any two-way communication. The *nonverbal* technique refers to communicating through nonverbal means, such as body language, eye contact, facial expression, and tone of voice. While communicating, you should always be mindful about the nonverbal component of communication. Communication competence refers to an overall ability to communicate, including components such as the clear delivery of the key message, awareness of purpose, creating relationship with receivers, and exhibiting leadership.

Note Communication skills, an essential part of general management skills, are used to ensure the following:

- The right stakeholders get the right information at the right time.
- The communication requirements and expectations of stakeholders are properly managed.

Interpersonal and Team Skills

Out of the interpersonal and team skills listed in Table 9-3, cultural and political awareness were already discussed in the planning communication section in this chapter, and conflict management was covered in Chapter 6.

Active Listening. This refers to paying attention to the speaker, acknowledging, asking for clarification in order in understand, and removing any hindrance in understanding communications.

Networking. According to the dictionary definition, networking is an interaction with other people to exchange information and develop contacts. You can network with stakeholders in project and departmental parties and at other social gatherings and settings. In this Information Age, you network using online tools and appropriate websites. Overall, this will help improving project communication and gaining more project support.

Meeting Management Techniques. Meeting management refers to organizing and conducting meetings. For effective and efficient meeting management, you can take the following steps:

- Send a timely invitation to all relevant—and only relevant—stakeholders and encourage them to attend.
- Prepare meeting agenda and make it available in advance; if possible, send it with the invitation and also distribute it at the beginning of the meeting.
- Use your communication skills, including conflict resolution, to conduct meeting.
- Start meeting on time, stay on agenda topics, and end it on time.
- During the meeting, invite appropriate participation.
- Manage expectations during the meeting.
- Take minutes, including action items and who attended.
- Follow up on action items after the meeting.

Given the same situation and communication technology and methods, one project manager may fail while the other may succeed. Why? The answer lies in the concept of effective communication.

Tools for Effective Communication Management

Managing communication effectively is more than choosing the right format, technology, and method. In short, it takes integrating many factors together; for example, using your communication skills to integrate appropriate technology, method, form, and content together to create a creative communication environment. This way, project communication goes beyond just the distribution of relevant information. For example, you must ensure that the right information is appropriately generated in the right form at the right time, is received by the right stakeholders, and is understood. Moreover, you also need to provide opportunities for stakeholders to make requests for further information, clarification, and discussion.

In the following, we discuss some techniques and overall basic communication concepts that, if applied properly, can help facilitate communication management.

Techniques for Effective Communication

Most of these techniques have already been discussed in detail in this chapter. Here, they are presented briefly in light of effective communication.

Sender–Receiver Models. To facilitate multichannel communication, feedback loops should be incorporated to provide interaction, encourage participation, and remove barriers to communication.

As discussed earlier in this chapter, the communication line has two ends. Both the sender and the receiver need to have communication skills in this environment. The sender has the following responsibilities:

- Ensure that the information is clear and complete.
- Confirm that the information is received and properly understood.

The receiver has the following responsibilities:

- Ensure that the information is received in its entirety.
- Ensure that the information is correctly understood.

So, the success of information distribution depends on both the sender and the receiver. That said, at the end of the day, it's the project manager's responsibility to make sure information is communicated successfully. The communication has two flavors in each of the following dimensions:

- **Making Media Choice.** Depending on the situation, you decide whether to communicate in writing or orally, write an informal memo or a formal report, and face-to-face conversation or e-mail. Whatever media you use, you will use communication skills to deliver the information.
- **Writing Style.** Appropriate writing is an essential part of good communication skills. It is important to know how to use active or passive voice, and how to use appropriate sentence structure and word choice in a given situation.
- **Meeting Management Techniques.** You prepare a meeting agenda and make it available in advance, and use your communication skills, including conflict resolution, to conduct meetings that stay on agenda and end on time.
- **Presentation Techniques.** Prepare and deliver a presentation centered around the main message using visual aids for greater impact while being aware of the impact of body language as well.

- **Facilitation Techniques.** Use your communication skills to actively clarify, acknowledge, confirm understanding, remove barriers by overcoming obstacles, resolve conflict, and build consensus on the common goal of process success.
- **Listening Techniques.** Listen actively to comprehend adequately and to respond effectively.

Also, awareness of basic communication concepts will help with effective communication.

Mechanism of Communication and Dimension of Communication Activities

Awareness of the mechanism of communication and the dimension of communication activities will help with effective communication because awareness leads to making the right choices. The basic issue here is to exchange information, which can be done in many forms, such as expressing emotions, sharing ideas, and giving instructions. However, you will need a mechanism for this exchange, such as the following:

- **Nonverbal or Through Gestures.** For example, body language, facial expressions, and tone of voice
- **Spoken Word.** For example, face-to-face, on phone, and through audio recordings
- **Written Word.** For example, on paper and on electronic media as on a website
- **Through Media.** For example, still and moving pictures, actions, choices of spoken words and then they are spoken—think of communication happening in a movie
- **Choice of Words.** For example, choosing words and phrases carefully to fine-tune the message; blunt or between the lines

Also, you should be aware and make appropriate use of the two-dimensional nature of some communication methods, features, or categories such as the following:

- **Place: External or Internal.** Internal to the project—that is, within the project—or external—that is, communicating to entities external to the project, such as customers, media, and the public
- **Format: Formal or Informal.** Formal, such as reports and briefings, or informal, such as e-mails, memos, and ad hoc conversation

- **Hierarchy: Vertical or Horizontal.** *Horizontal* means communication among peers—e.g.; other project managers; *vertical* means communication between different levels of the organizational hierarchy—for example *upward* (senior managers) and *downward* (team members and other stakeholders working for the project).
- **Official or Unofficial.** Examples: official newsletters and annual report; unofficial off-the-record conversation
- **Written or Unwritten.** Examples: written e-mail, unwritten oral and verbal talk and nonverbal body language

You use these tools and techniques to generate the output of the Manage Communication process.

Tip Effective communication management builds bridges between diverse stakeholders with different cultures, backgrounds, discipline of knowledge, interests, and opinions.

Output of Manage Communication Process

The output of the Manage Communication process is as follows.

Project Communications

The main output of the Manage Commination process is project communications, which are artefacts of project communication, such as performance reports, presentations, e-mails, memos, deliverables' status, incurred costs and earned value graphs, and schedule progress.

Organizational Process Assets Update

The Manage Communication process will create some items that can be added as a record to the organizational process assets. Here are some examples:

- Project reports, including status reports
- Stakeholder notifications about resolved issues and approved changes
- Project presentations
- Project records, such as memos and meeting minutes, and project files, such as plans and schedules

- Feedback from stakeholders
- Lessons learned

Project Document Update

As a result of this process, some project documents may be updated; see Study Checkpoint 9.3.

STUDY CHECKPOINT 9.3

Q1. Knowing the Manage Communication process, how do you think documents listed for update in Table 9-3 would be updated?

Q2. Why do you need the project stakeholder engagement plan for performing the manage communication process?

Caution! Distinguish between communicating, the singular, and communications, the plural. *Communication* refers to the act of communicating, such as conducting a meeting or sending an e-mail, while *communications* refers to the artifacts of communication, such as meeting minutes, memos, e-mails, and progress reports.

How will we know how we are doing in the communication aspect of the project? Well, we need to monitor the communication.

Monitor Communication

The Monitor Communication process makes sure that the information needs of the project stakeholders are met throughout the entire project lifecycle as planned in the communications management plan and stakeholder engagement plan. It can trigger reruns of the Plan Communication Management and Manage Communication processes to improve the results of communication.

Tip Monitor Communication is a high-level process in the sense that it oversees the Plan Communication Management and Manage Communication processes to fine-tune them in order to optimize the effective information flow among all participants in project communication, at any and all times.

While you are directing and managing the project work, the work results and the progress toward creating the project results are produced. Just producing the results is no guarantee of success. Success is determined by the performance with which the results are being produced. You need to know the performance to keep the project on the right track. Furthermore, the stakeholders need to know with what rate, efficiency, and work quality the resources are being used to deliver the project output. For this, you need to collect the project performance data and evaluate different aspects of the project and whether they are meeting expectations. In this process, we are interested in the communication aspect of the project—whether communication is gaining the targeted stakeholder support for the project.

Caution! All performance indicators are not equal. You must evaluate the impact and implications of each deviation. For example, a performance deviation or other issues with key performance indicators, such as actual versus planned schedule, cost, and quality, may trigger an immediate alarm, while others may not. In case of an alarm, the right message must be delivered to the right stakeholders at the right time, which can lead to a revision by rerunning the appropriate process or processes.

The Monitor Communication process is presented in Table 9-4 in terms of its inputs, tools and techniques, and outputs.

Table 9-4. The Monitor Communication Process: Input, Tools and Techniques, and Output

Input	Tools and Techniques	Output
1. Project Management Plan: • Communication management plan • Stakeholder engagement plan • Resource management plan 2. Project documents: • Project communications • Issues log • Lessons learned register 3. Work performance data 4. Enterprise environmental factors 5. Organizational project assets	1. Data reorientation: • Stakeholders' engagement assessment matrix 2. Interpersonal and team skills: • Observation/ conversation 3. Information management systems 4. Expert judgment 5. Meetings	1. Work performance information 2. Change requests 3. Project management updates: • Communication management plan • Stakeholder engagement plan 4. Project document updates: • Stakeholder register • Lessons learned register • Issues log

Performing the Monitor Communication Process

The purpose of monitoring communication is two-fold: 1) ensure that the right information is being distributed to the right stakeholders at the right time by using the right methods; and 2) check this by evaluating the project—e.g.; gaining the expected project support from stakeholders, and if not, generating change requests in the communication plan and management.

With this in mind, the core of performing the Monitor Communication process is explained in the following steps using the input and tools and techniques from Table 9-4.

Get Communication-related General and "How-to" Information. From the *resource management plan*, fetch current information about project organization in terms of roles and responsibilities; project organization charts will be useful. From the *communication management plan*, learn about current plan for generating/collecting, storing, and distributing information. You can find out the communication strategies from the *stakeholder engagement plan*. Also, the communication management plan would provide guidance on running the Monitor Communication process.

Get the Project Execution Data and Results on Communication. The input item *work performance data* from project execution includes information about the type and quantity of information that was distributed. Also, you can find out which communication items or artefacts were distributed from *project communications*.

This data provide a good picture of what were distributed, to whom, and using which technology and methods. The next step is to analyze and evaluate the impact of this communication on both the stakeholders and the project.

Analyze Communication and Its Impact. To monitor and analyze communication and its impact, do the following:

1. Review record of stakeholder's engagement issues from *issues log* including open and resolved issues.
2. Review the lessons learned data from *lessons learned register*. It may suggest communication-related changes.
3. Evaluate the stakeholder, e.g.; customer, satisfaction surveys.
4. Review the *stakeholders' engagement assessment matrix* and compare the current engagements of stakeholders with the desired ones. This would indicate how effective the current communication is.

5. Use tools provided by PMIS on communication data, including stakeholder surveys, stakeholders' engagement assessment matrix, issues log, etc. to assess the effectiveness and impact of communication.
6. You can use your *interpersonal and team skills* such as *observation* and *conversation* to work with team to accomplish tasks like the following:
    - Determine more efficient and effective way to update project performance information and distribute it.
    - Determine how to better respond to stakeholder's requests.
    - Based on preceding reviews and evaluations, determine what changes should be made to communication management plan and *stakeholder engagement plan* to make communication more effective.
    - Of course, you will also be using *meetings* for these and other controlling communication tasks.
7. All these reviews, from steps 1 to 6, can contribute to generating *work performance information* and *change requests*, the main outputs of this process.

Work Performance Information. This document contains information about how project communication is performing and about communication impact on the stakeholders. This is obtained by comparing communication as it actually happened with as it was planned. This is done by actions performed in steps 1 through 4—evaluating customer satisfaction surveys and stakeholder feedback and comparing the current engagement levels of stakeholders with the desired levels in the stakeholders' engagement assessment matrix.

Work performance information would be put into the Monitor and Control Project Work process to create a work performance report, which in turn would be communicated using the Manage Communication process.

Change Requests. The monitoring of communication, such as by steps 1 through 5, may reveal the need to make communication changes to obtain the planned or expected results. The changes could be in any aspect of communication, such as format, content, or the way it's distributed. Changes could also include new methods and procedures, such as to improve efficiency.

The change requests generated by the Monitor Communication process, or by any other process, must be processed through the Perform Integrated Change Control process.

Update Documents. Because project communication is performed according to the *communications management plan* and the communication strategies found in the *stakeholder engagement plan*, these documents may be modified as a result of the acceptance or implementation of communication changes.

Some new issues may arise and some existing issues may get resolved, stakeholder communication may change, and some lessons may be learned, such as which communication method worked better for a particular group of stakeholders, so, accordingly, the issues log, stakeholder register, and lessons learned register may need to be updated.

Caution! Do not confuse the Monitor Communication process with the Manage Communication process, even though you must recognize they are closely related and may seem to overlap. Remember the link between them: work performance information, a main output of the Monitor Communication process, is put into the Monitor and Control Project Work process to create a work performance report, which in turn would be communicated using the Manage Communication process.

STUDY CHECKPOINT 9.4

In the following table, match each item in the first column to one or more items in the second column in the context of its role in communication management.

Item	Role
A. Work performance data	1. Input to Monitor and Control Project Work
B. Work performance information	2. Output of Monitor Communication
C. Work performance reports	3. Output of Monitor and Control Project Work
D. Project communications	4. Output of Direct and Manage Project Work
	5. Input to Monitor Communication
	6. Input to Manage Communication
	7. Output of Manage Communication

The three most important takeaways from this chapter are the following:

1. Communication is a common thread that runs through the project lifecycle. So, it's important to develop a communication plan early in the project.
2. As in managing stakeholder engagement, one main purpose of managing communication is keeping and gaining the stakeholders' support. With this in mind, communication is managed according to the communication management plan and stakeholder engagement plan to implement the mantra: deliver the right information to the right people at the right time by using the right communication methods to produce the desired impact.
3. The Monitor Communication process is used to ensure that communication is happening as planned in the communication management plan and stakeholder engagement plan, and as a result the targeted stakeholder support for the project is being obtained.

Summary

Communication is the common thread that runs through almost all activities and processes in project management. There are three communication processes: plan communication to determine communication; manage communication to make it happen; and monitor communication to ensure it happened. The key to the project and the mantra of effective communication is the distribution of the right information to the right stakeholders at the right time by using the right communication methods to create the desired impact.

To determine how to do this, you need to plan communication, for which you need to identify stakeholders and develop a stakeholder management strategy. The communication is managed and controlled according to the communication management plan, and also according to the stakeholder engagement plan, which contains the stakeholder communication strategies. In the Manage Communication process, reports—such as work performance reports, quality report, and risk report—and information is distributed to the stakeholders at the right time using the right communication methods.

The Monitor Communication process oversees that communication is actually happening as planned and having the desired impact. If it's not, change requests are generated to correct the situation.

Road Ahead. Recall from this chapter that the quality report and risk report are input into the Manage Communication process. These reports come from quality management and risk management. We will cover quality management

in the next chapter, followed by a chapter on risk management; both are in the last part of this book. This last part will also include a chapter on project procurements management that contains processes for acquiring products, services, or results for the project from outside the project.

Exam's Eye View

Comprehend

- Plan Communication is the process of determining the information needs of the project stakeholders and accordingly determining which tools and methods to use to meet those needs by producing, storing, and delivering the information.
- Effective communication management builds bridges between diverse stakeholders with different cultures, backgrounds, disciplines of knowledge, interests, and opinions.
- Work performance data, generated by the Direct and Manage Project Work process, is used as an input to the Monitor Communication process to generate work performance information.
- Work performance information would be put into the Monitor and Control Project Work process to create a work performance report, which in turn would be communicated, along with other reports, using the Manage Communication process.

Look Out

- Communication requirement analysis is performed to determine the communication needs of the project stakeholders and to optimize the use of the communication resources for project success.
- Communication plays a critical role in keeping the stakeholders engaged in the project.
- Distinguish between communicating, the singular, and communications, the plural. *Communication* refers to the act of communicating, such as conducting a meeting, while *communications* refers to the artifacts of communication, such as meeting minutes.
- Distributing information means distributing all the relevant information, whereas performance reporting focuses on the performance part of the information.
- To manage and monitor communication, the stakeholder engagement plan is also used, along with the communication management plan, because it explains how to use appropriate stakeholder communication strategies to engage the stakeholders.

Memorize

- The factors that can contribute to determining the communication technology to be used include availability, project environment, project length, urgency of the information need, ease of use, and confidentiality of information.
- Distributing the right information to the right stakeholders at the right time by using the right communication method is the mantra in communication management.
- Performance reports are important, but along with them, other reports and information are also distributed to stakeholders.
- The process of manage communication significantly adds to the organizational process assets in the form of project reports, status reports, project presentations, stakeholder notifications, and other project communication artifacts and records.

Review Questions

1. Which of the following communication skills are necessary for a project manager?

   a) Listening, b) negotiating, c) resolving conflict, d) pursuing a team, e) setting expectations

   Select the most correct answer:

   A. All except a

   B. All except a and e

   C. All except d

   D. All

2. You want to ensure that messages are delivered and understood. Which communication model would you implement for that to happen?

   A. Basic sender–receiver communication model

   B. Basic interactive communication model

   C. More complex interactive model

   D. B or C

3. You are trying to understand the message sent to you by one of your team members, who lives on the other side of the globe. The team member has used lots of local phrases and acronyms that you are trying to understand. According to the basic communication model, what are you dealing with here?

   A. Noise and decoding

   B. Encoding and feedback

   C. Message and feedback

   D. Broken English

4. Which of the following is not an output of communication planning?

   A. Methods of communication

   B. Communication constraints

   C. Frequency of reporting the project status

   D. Stakeholder management strategy

5. Which of the following is not an output of the Manage Communication process?

   A. Work performance information

   B. Project risk reports and status reports

   C. Performance reports and quality reports

   D. Project presentation

6. The issues log is not an input used in the following process:

   A. Plan Stakeholder Engagement

   B. Plan Communication Management

   C. Manage Communication

   D. Monitor Communication

7. What of the following is not a part of communications?

   A. Presentations

   B. Emails

   C. Risk reports

   D. To send an e-mail message

8. Which of the following is not an input to the Manage Communication process?

   A. Risk report

   B. Resource management plan

   C. Project communications

   D. Stakeholder engagement plan

9. Which one of the following items will be certainly updated as a result of the Manage Communication process?

   A. Enterprise environmental factors

   B. Organizational project assets

   C. Work performance report

   D. Resource management plan

10. You have created the work performance report about the project that you are managing. Which process will you use to distribute the report among the stakeholders?

    A. Manage Stakeholders

    B. Distribute Reports

    C. Distribute Information

    D. Manage Communication

11. The sponsor of your project wants to look at the raw data from executing the project—that is, the work performance data. Which process should you run to get this information?

    A. Manage Communication

    B. Execute Project

    C. Direct and Manage Project Work

    D. Monitor Communication

12. The sponsor of your project wants to look at the work performance information. Which process should you run to get this information?

    A. Monitor and Control Project Work

    B. Manage Communication

    C. Direct and Manage Project Work

    D. Control Scope, Control Schedule, Control Cost, or Monitor Communication

13. The Monitor Communication process is performed according to the following plan or plans: (choose the best answer)

    A. Communication plan

    B. Stakeholder engagement plan

    C. Stakeholder management plan

    D. Communication plan and stakeholder engagement plan

PART

IV

Quality, Risk, and Procurement

By the very definition of *quality*, a project cannot possibly be completed without implementing quality, as quality can be looked upon as the degree to which the characteristics of project deliverables, project objectives, and project requirements are fulfilled. With quality, and in all areas of project management, we make assumptions and estimates and face constraints. These other sources of uncertainty can give rise to risks, which must be dealt with.

There may be some expected outcome items of the project that will not be developed by the project team, but rather will be purchased or acquired—a process called *procurement*.

So, in this last part of the book, we will cover quality management, risk management, and procurement management.

CHAPTER

10

Project Quality Management

The objectives covered in this chapter make up 7 percent of the exam, equivalent to about 9 questions. Study the whole chapter in detail.

It's enough to just remember the name of the input, tools and techniques, and outputs. You should know what is in a given input item that the given process uses and how it helps generate the output, as well as what a given tool or technique does in a given process.

You should understand very well how to apply quality management tools and methods of such as logical data model, mind mapping, root-cause analysis, audits, and process analysis.

While studying this knowledge area and its processes, pay attention to how the tasks can be tailored to your needs, and also recognize an agile environment in action; e.g.; continual assessment generates change requests, which lead to changing plans—i.e., adapting.

P. Sanghera, *CAPM® in Depth*, https://doi.org/10.1007/978-1-4842-3664-2_10

CAPM Exam Objectives

Project Quality Management:

1. Understand the three project management processes in the project quality management knowledge area.
2. Identify the input, tools and techniques, and outputs defined in the three quality management processes.
3. Understand the reasons for and approaches to adapting quality management in different project environments.

Project work is incomplete without implementing quality, and an incomplete project is obviously a failed project. Quality refers to the degree to which a set of completed characteristics of project deliverables and objectives fulfills the project and product requirements. It is about delivering the complete and correct product in the right way. The "right way" refers to the project quality—according to planned schedule and cost. In other words, the core objective of quality management is to ensure that the project will satisfy the needs and requirements for which it was undertaken. Accordingly, quality management consists of three core elements: planning quality management, managing the quality, and controlling the quality. Quality management includes managing the quality of both the project and its product. Whereas the techniques of product quality management, such as measuring the quality, may depend on the type of product, the techniques for project quality management are independent of the type of product.

The core question in this chapter is: How do you mange quality? In search of an answer, we will explore three avenues: planning quality management, managing quality, and controlling quality.

Managing Quality: Big Picture

The knowledge area covering quality has three processes, explained in the following list:

- **Plan Quality Management.** This process is used to identify which quality requirements and standards are relevant to the project at hand and how to determine whether that project and its deliverables meet these requirements and conform to the standards.
- **Key:** Identify quality requirements.
- **Manage Quality.** This process develops tests, evaluation procedures, and other activities based on the quality management plan and quality control measurements taken in the Control Quality process.

- **Key:** Develop test and evaluations.
- **Control Quality.** This process executes the activities developed in the Manage Quality process to verify that the project and its deliverables meet the quality requirements and conform to the quality standards.
- **Key:** Verify by executing the activities.

Table 10-1 presents the list of processes of quality management along with the major output of each process and the process group it belongs to.

Table 10-1. Processes of Quality Management Mapped to the Process Groups

Quality Management Process	Process Group	Major Output	Performed
Plan Quality Management	Planning	Quality management plan Quality metrics	Once or at pre-defined points
Manage Quality	Executing	Quality reports Test and evaluation documents Change requests	Throughout the project
Control Quality	Monitoring and Controlling	Quality control measurements Verified deliverables Change requests	Throughout the project

Caution! In addition to the three quality management processes shown in Table 10-1, the performing organization might have its own quality policy and procedures, which will need to be incorporated into quality management by the Manage Quality process.

The big picture of quality management is presented in Figure 10-1, where the two processes named in oval-shaped boxes do not belong to quality management but, as shown, interact with it in an important way.

Figure 10-1. Processes of quality management in a big picture

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Note Two outputs, *quality reports* and *verified deliverables*, of quality management are used by processes in other knowledge areas.

Before talking about quality planning, let's take a look at a few quality concepts.

Some Concepts in Quality

In this section, we will discuss some general concepts in quality. While dealing with quality, you should be able to distinguish between the terms in the following pairs:

- **Grade and Quality.** Grade is a category assigned to products with the same overall functional use but differing technical characteristics and features, whereas quality is the degree to which the inherent characteristics of a product meet the requirements. A number of defects is an example of poor quality, whereas a limited number of features is an example of low grade.

- **Precision and Accuracy.** Precision is the spread of different measurements of the same quantity, constant, or variable, such as gravity or cost. The smaller the spread of measured values the better the precision is. Accuracy is a measure of how close the measured values are to the true value of the quantity. The closer the measured value is to the actual (or true) value, the better the accuracy of the measurements is.
- **Prevention and Inspection.** Prevention is a direction to perform an activity that will keep an error from entering the product and the process. Inspection is a technique to examine whether an activity, component, product, result, or service complies with the planned requirements. So, the goal of inspection is to ensure that errors do not reach the customer.

Note Although quality treatment in PMBOK does not talk about precision and accuracy that much, we have discussed these concepts here because of their importance for project managers.

Project management and quality management have come a long way as separate disciplines of knowledge and practice. It should not come as a surprise that quality management is one of the ten knowledge areas in standard project management. In a complementary way, both modern quality management and project management recognize the importance of the following critical issues:

Continuous Improvement. Continuous improvement means to keep improving the quality through a process of planning for quality, implementing quality, auditing quality, and re-planning based on lessons learned or auditing. So, really, quality improvement is an endless cycle, called the plan-do-check-act cycle, as defined by Shewhart and modified by Deming. Performing organizations can also use techniques such as Six Sigma TQM to improve the quality.

Customer Satisfaction. Customer satisfaction can be a very vague notion that could mean different things to different parties. However, in project management and quality management, customer satisfaction means planned customer requirements are met. In order to achieve customer satisfaction in the real world, you need to understand, define, and evaluate customer expectations and also manage those expectations,

in addition to meeting the planned requirements. Otherwise, you might meet the planned requirements, and the customer may still be dissatisfied. Bypassing the proper quality procedure will cost customer satisfaction and lead to more costs on rework.

Management Responsibility. This refers to the responsibility of the management to provide the resources needed for the project team to succeed. Although all team members should be responsible for the success of their parts of the project, they cannot succeed without management fulfilling its responsibilities.

Prevention over Inspection. One of the fundamental tenets of modern quality management is: plan, design, and build in quality as opposed to inspect in quality. The cost of preventing mistakes is much less than finding them through inspections and then fixing them. Therefore, the cost of quality (COQ) is less in prevention than through inspection. The COQ is defined as the total cost of quality-related efforts throughout the product lifecycle.

STUDY CHECKPOINT 10.1

You are trying out a Monte Carlo simulation program that estimates the value of a parameter by using some random variables. You know through the data that the exact value should be 40. You ran the program three times and it gave you three values: 50, 51, and 52. Based on these values, answer the following questions:

Q1. How precise is the program in making the estimates?

Q2. How accurate are the estimates?

Q3. Are the values generated by the program more accurate or more precise?

The process for managing quality is part of executing the project, quality control is used as part of monitoring and controlling the project, and quality planning is performed during the project planning stage and is discussed next.

Planning Quality

Planning quality management is the process to accomplish the following:

- Identify quality requirements and standards for the project and its deliverables.
- Determine how to test and verify that the quality requirements have been implemented and standards have been conformed to.

Table 10-2 presents the Plan Quality Management process in terms of input, tools and techniques, and output.

Table 10-2. The Plan Quality Management Process: Input, Tools and Techniques, and Output

Input	Tools and Techniques	Output
1. Project charter 2. Project Management Plan: • Scope baseline: scope statement, WBS, WBS dictionary • Stakeholders management plan • Requirement plan • Risk management plan 3. Project document: • Requirement documentation • Requirement traceability matrix • Assumptions log • Risk register • Stakeholder register 4. Enterprise environmental factors 5. Organizational project assets	1. Data gathering: • Benchmarking • Brainstorming • Interviews 2. Data Analysis: • Cost-benefit analysis • Cost of quality 3. Decision making: • Multicriteria decision analysis 4. Data presentation: • Flow charts • Matrix diagrams • Logical data model • Mind mapping 5. Test and inspection planning 6. Expert judgment 7. Meetings	1. Quality management plan 2. Quality metrics 3. Project Management Plan: • Scope baseline • Risk management plan 4. Project document updates: • Requirement traceability matrix • Stakeholder register • Risk register • Lessons learned register

Core of Planning Quality Management

As discussed earlier, planning quality management consists of identifying quality requirements and standards for the project and its deliverables and determining how to test and verify that the quality requirements have been implemented. To make sense of the following material, you should know the story of quality management as it relates to the project and its stakeholders. The stakeholders have some project and product needs and requirements, including quality requirements, the fulfillment of which is affected by quality-related assumptions and constraints. In this light, the Plan Quality Management process may be explained in the following steps in terms of the items from Table 10-2:

1. **Get Background and Reference "How-to" Information.** From the *requirement management plan*, extract the information on how the requirements were identified, analyzed, and managed. As stakeholders' needs and expectations are crucial to managing quality, get the information from the *stakeholder engagement plan* on what methods were used to document the stakeholders' needs and expectations. As risk and quality are closely related, from the *risk management plan* get information on how risks were identified, analyzed, and monitored.
2. **Determine Quality Standards.** Quality standards and quality objectives can, at least partially, be determined by using WBS and deliverables in the project scope statement, which are parts of the project *scope baseline*. The acceptance criteria for deliverables is in the *scope baseline*, and measurable project objectives linked to project success criteria in the *project charter* will also help this determination as well as influence quality management.
3. **Get Information about Deliverables and Quality Requirements.** Fetch the quality requirements for the project and its product from the *requirement documentation*. Then, link the product requirements to deliverables using the *requirement traceability matrix*. This helps make sure that each requirement is tested through the Manage Quality process. The requirements will be compared with the actual project results in the Control Quality process.

4. **Get Quality Assumption and Risk Information.** Extract quality-related assumptions and constraints from the *assumptions log*; get the risks and opportunities from the *risk register* that can influence or impact quality. There, assumptions and risks are used to determine how to perform the Manage Quality and Control Quality processes.

5. **Get Stakeholder Information.** Use the *stakeholder register* to identify the stakeholders with specific interest in specific quality items. This will help with prioritization—e.g.; quality interests of customers and the project sponsor will be high on priority list. This information will also help to determine how to perform the Manage Quality and Control Quality processes.

Use the tools and techniques listed in Table 10-2 to convert the information from steps 1 through 5 into *quality metrics* and a *quality management plan*.

If the performing organization lacks a quality policy, the project team will need to develop one for the project. Once a quality policy is in place, it is your responsibility to ensure that the project stakeholders are aware of it and are on the same page.

Some of these tools will be explained in the next section.

Tools and Techniques Used for Quality Planning

The tools and techniques used for quality planning include benchmarking, cost-benefit analysis, experiment design, brainstorming, and more.

Data-Gathering Techniques

The following data-gathering techniques can be used to gather data in order to identify quality requirements and standards and for other matters regarding planning quality management.

Benchmarking. Benchmarking is comparing the practices, products, or services of a project with those of some reference projects for the purpose of learning, improving, and creating the basis for measuring performance. These reference projects might be previous projects performed inside or outside of the performing organization. Improvement and performance are of course quality-related factors, in this case. For example, you might have a similar project performed in the past that accepted no more than two defects in each feature. You might use that as a quality criterion—a benchmark—for your project. The benchmarked project could be in the same or different industry as the current project is in, same or different application area, and inside or outside the performing organization.

Brainstorming and Interviews. Brainstorming and interviews, covered in Chapters 3 and 4, can also be used in this process. For example, brainstorming sessions in a group environment can be held with team members and quality experts during the process of developing the quality management plan. Similarly, interviews can be conducted with appropriate stakeholders to collect information regarding planning quality matters, such as project and product quality needs.

Data Analysis

To select the best of several alternatives available in implementing quality, the following data analysis techniques can be used.

Cost of Quality. Cost of quality is the total quality-related cost during the lifecycle of the project and the product. That includes the costs incurred in implementing conformance to the requirements as well as cost of nonconformance.

The cost of conformance consists of prevention costs and appraisal costs. Prevention costs include the costs of implementing quality, such as for appropriate equipment, documenting and performing processes, time and effort to perform the project work the right way, and needed training for team members. The appraisal costs include the cost of inspecting, testing, and loss due to destructive testing. Destructive testing refers to tests in which the product under test is destroyed or harmed by design.

Cost of nonconformance refers to the cost of failure—both internal failure and external failure. Internal failures, i.e., failures found during the project, include rework and waste (for example, the product is rejected internally because it did not meet the quality standards, so it's now scrap). External failures, i.e., failures found by the customers, include warranty work and more fatal consequences, including liabilities and loss of business.

Cost-benefit Analysis and Decision-making Techniques. During quality planning, you must consider the tradeoff between the cost and the benefit of implementing quality, striking the appropriate balance for a given project. Cost-benefit analysis is performed to choose the best of several alternatives available in implementing quality. The chosen alternative will have minimum work and cost and maximum productivity and rise in stakeholder satisfaction and expected benefit.

The decision-making technique of multicriteria decision analysis, explained in Chapter 6 in the context of resource selection, can be combined with cost-benefit analysis to select the best of the alternatives available for implementing quality. This decision-making technique can be used for decision making in other quality-planning matters, such as prioritizing quality metrics.

Data Presentation

Data presentation techniques are used for various purposes: 1) examine data integrity; 2) find the key quality metrics; 3) establish quality requirements; 4) understand and estimate the cost of quality for a process; 5) improve the process, and 6) identify points where quality defects may occur.

Some of them are discussed next.

Matrix Diagrams. This method is used to explore the strength of the relationships between different entities, such as objectives and causes, by displaying these entities in a matrix, with cells of the matrix representing the relationships. These relationships are explored to find the key quality metrics important for project success.

Logical Data Model. In this technique, the relevant data from the organization is visually presented in business lingo and does not depend on any specific technology. This is a visual display via which quality-related logical loopholes such as data integrity are discovered.

Mind Mapping. This is a diagrammic technique, explained in Chapter 4, in which various ideas from information collected through various means and methods are mapped around a central or key concept in order to expose commonalities and differences among ideas. In quality planning, each key concept would be a single quality concept linked to various ideas around it. This technique may help in figuring out quality requirements, constraints, and relationships, such as dependencies.

Test and Inspection Planning. When, during the planning stage of your project, you are planning the tests and inspections of the project outcome that will see if it meets the stakeholders' needs and expectations, these tests and inspections should cover the quality aspect as well. These quality-related tests and inspections depend on which industry the project belongs to; e.g.; field tests in some sciences, inspections in manufacturing, strength tests in construction and manufacturing, and alpha beta tests in software engineering.

Flowcharts. Also called process maps, flowcharts visually display the sequence of steps of a value chain, including the process converting input into output. A value chain, in general, may include activities, decision points, branching possibilities, and parallel paths. As a simple example of flowcharts, Figure 10-2 presents a version of a value chain called SIPOC, which stands for supplier, input, process, output, and customer. How do you obtain information from these flowcharts? The answer: 1) figure out frequencies associated with workflow branches; and 2) use these frequencies to estimate the monetary value of quality conformance and the cost of rework in case of nonconformance.

These flowcharts have multiple uses, including 1) understanding and estimating the cost of quality for a process; 2) improving the process; and 3) identifying points where quality defects might occur.

Figure 10-2. The SIPOC value chain flowchart

Of course, you will be holding meetings to collect the information and develop the quality management plan.

Caution! Part of the cost of quality is the failure cost, which is the cost of the rework resulting from the failure to meet the requirements during product development. Failure cost, also called cost of poor quality, is grouped into two categories: external failure cost, which is the cost of fixing problems found by the customer, and internal failure cost, which is the cost of fixing problems found within the project. Failures occurring at the hands of the customers can also result in fatal consequences, including law suits and loss of business.

You usually use more than one of these techniques to generate the output of quality planning.

Output of Quality Planning

A major output of the quality planning process is the quality management plan and quality metrics.

Quality Management Plan. The quality management plan contains the following information:

- What are the quality-related roles and responsibilities assigned to each role?
- What are the project and deliverable quality requirements and standards for this project?
- Describes what and how the quality-related policies, procedures, and guidelines will be applied to achieve the project quality objectives; e.g.; procedures to deal with continuous improvement, nonconformance, and corrective action
- What resources will you or project management need to meet the project quality objectives; e.g.; the quality tools to be used?
- What are the quality objectives for this project?

- Describes activities of the quality management and quality control processes for this project.
- Which deliverables and processes will go under quality review?

This plan becomes a component of the overall project management plan.

Tip Whether the quality management plan is informal and high-level or formal and detailed depends upon the size, complexity, needs, and requirements of the project.

Quality Metrics. A metric in quality metrics is a product attribute accompanied by the information on how the quality control process will verify its quality conformance. For example, it is not specific enough to say the defects in the product will be minimized. Rather, specifying something such as that no feature will have more than two defects is a measurable criterion and hence a metric. Some examples of quality metrics are cost performance in CPI; schedule performance, e.g.; percentage of task completed in time; defect frequency, e.g.; number of defects experienced per day; failure rate; and downtime per week. The metrics that you set during quality planning will be used in quality management and quality control.

STUDY CHECKPOINT 10.2

Knowing the Plan Quality Management process, answer the following:

Q1. Describe which EEFs can influence this process.

Q2. Describe which OPAs can influence this process.

Q3. Describe how the documents listed in the output column of Figure 10-2 will be updated.

Once you have prepared the quality management plan, you have to ensure that the quality is being implemented according to the plan. You do that by managing quality, discussed next.

Managing Quality

Quality planning is used to identify quality requirements and standards relevant to the project and its product and to determine how to implement those. Actual implementation is carried out in two processes: Manage Quality and Control Quality. The Manage Quality process implements the quality plan by executing some quality activities in light of the organization's quality policies to examine quality measurements.

Performing organizations typically have a department called Quality Assurance (QA) that oversees the quality assurance activities and fosters continuous process improvement, which is an iterative method for improving the quality of all processes. Your project management team can work with the QA department.

Tip Continuous process improvement enhances the efficiency and effectiveness of the processes by minimizing waste (unnecessary activities) and duplication of efforts. It includes identifying and reviewing the business processes inside the organization, such as the coding of modules within software programs and the process of project approval.

In project management, while quality assurance only focuses on project process improvement, quality management includes quality assurance and project product design and process improvement.

Table 10-3 presents the Manage Quality process in terms of input, tools and techniques, and output.

Table 10-3. The Manage Quality Process: Input, Tools and Techniques, and Output

Input	Tools and Techniques	Output
1. Project Management Plan: • Quality management plan 2. Project documents: • Quality control measurements • Quality metrics • Risk report • Lessons learned register 3. Organizational project assets	1. Data gathering: • Checklists 2. Data analysis: • Root-cause analysis • Process analysis • Alternatives analysis • Document analysis 3. Decision making: • Multicriteria decision analysis 4. Data presentation • Affinity diagrams • Flow charts • Cause and effect diagrams • Matrix diagrams • Histograms • Scattered diagrams 5. Audits 6. Design for X 7. Problem solving 8. Quality improvement method	1. Quality reports 2. Test and evaluation documents 3. Change requests 4. Project management plan updates: • Quality management plan • Scope baseline • Schedule baseline • Cost baseline 5. Project document updates: • Risk register • Issues log • Lessons learned register

Core of Performing Quality Management

The main input to the Manage Quality process comes from quality planning, directing, and quality control. Performing the Manage Quality process can be explained in the following steps in terms of the items from Table 10-3:

1. **Get "How-to" Information.** This process is performed according to the *quality management plan*. The following information in this plan will be very helpful: acceptable quality levels for project and its deliverables; how to check that this level has been implemented; and what to do with the items that are found not to meet this quality level, e.g.; start a change request.
2. **Get Quality-Related Risk Sources.** Use the *risk report* to identify the sources of overall project risks that can impact the project's quality objectives.
3. **Get Quality Control Measurements.** These are found in the *quality control measurements* document, an output of the Control Quality process discussed later in this chapter. Compare these quality measurements for project processes and deliverables against the quality requirements and standards that are supposed to be met. This will need analysis and the techniques from Table 10-3.
4. **Get Quality Metrics.** The *quality metrics* are an output of planning quality. Use them as a reference or basis for developing the test of quality and for suggesting improvement; e.g.; change request.
5. Using the information from these steps and other reports, review, examine, analyze the result, and develop tests to verify quality.

From the information produced in steps 1 through 5, generate quality reports and develop tests, evaluation documents, and change requests—the output of this process.

To develop quality reports and tests and evaluations to examine and test quality, you use a host of tools to explore different quality aspects and issues, such as the following:

1. Verify that a set of required steps has been performed and a set of requirements has been met.
2. Rank the defects; determine the relationship between different project elements and defects; and identify the root causes of quality problems, and a cause leads to a defect, and important areas that cause quality problems.

3. Identify problematic processes that may create obstacles in meeting quality requirements.
4. After finding faulty processes, determine how they can be improved and identify the root causes of quality problems.
5. Explore different quality options and approaches in order to select the best one to apply.
6. Make quality-related decisions about projects and products.

Some of these tools and techniques are discussed next.

Tools and Techniques for Performing Quality Management

The techniques and methods used in quality management are listed in Table 10-3 and discussed in the following sections.

Data Gathering and Data Analysis

You can use the data-gathering technique called checklists, discussed in the next section on quality control, to verify that a set of required steps has been performed and a set of requirements has been met.

In managing quality, data-analysis tools can be used to find faulty processes, determine how they can be improved, identify the root causes of quality problems, and so forth. The data-analysis techniques that can be used for managing quality include root-cause analysis, document analysis, and alternatives analysis. You will use *alternatives analysis*, explained in Chapter 6, to explore different options and approaches in order to select the be st one to apply. Other data-analysis processes are discussed next.

Document Analysis. In this process, you can use document analysis to identify problematic processes that may create obstacles in meeting quality requirements. Document analysis involves accessing the relevant documents, studying them, and extracting the needed information from them. In this case, the relevant documents would be the ones generated as outputs of the control processes, such as performance reports, test reports, and variance analyses. You will be analyzing such documents to identify problematic processes.

Root-cause Analysis. This is a general method to solve a problem. It involves collecting information about the problem and analyzing it to find the root causes. The problem's solution would lie in removing all the root causes. This approach can also be used in managing quality to identify the root causes of various defects and risks, and also to address other quality problems. Once the root cause of the defect is found, you can examine the possibility of that root cause generating other defects.

Process Analysis. This is a technique used to identify the ways a process can be improved. It examines the problems, constraints, and unnecessary (non–value added) activities identified during the implementation of the process. Process analysis also typically includes examining the following:

1. Problems in the process
2. Constraints faced or caused by the process
3. Process waste: activities with little or no value that happen while performing the process

Data Presentation

Data-presentation techniques are used for various purposes, such as to quantify and rank the defects; expose the relationship between different project elements and defects; and identify the root causes of quality problems, how a cause leads to a defect, and how important areas cause quality problems.

In this process, *affinity diagrams,* covered in Chapter 4, can be used to identify the most important areas of causes of defects or other quality problems on which we should focus. Using affinity diagrams, causes are organized into groups, and these focus areas are identified.

You can use the *flowcharts*, discussed in the plan quality section, to identify the series of steps that lead to a defect or other quality problem. *Matrix diagrams* can be used to find the strength of the relationships between objectives, causes, and factors by examining the rows and columns of the matrix.

Cause and effect diagrams, histograms, and scattered diagrams are discussed in the next section.

Decision Making: Mmulticriteria Decision Analysis

The decision-making technique of multicriteria decision analysis, explained in Chapter 6 in the context of resource selection, can be used in managing quality to make quality-related decisions about projects and products. Some examples are choosing from between different approaches to quality implementation and, while dealing with defects, choosing from different options regarding schedule, cost, stakeholder satisfaction, and product lifecycle.

Quality Audit

An audit, in general, is a structured and independent review to check or verify compliance with some of the policies, processes, and procedures. In project management, a quality audit is an independent review to check whether project activities comply with the policies, processes, and procedures of the

project and the performing organization. Audits can occur as scheduled or at random and can be conducted by a third party or by properly trained in-house auditors of the performing organization. The main objectives of quality audits are the following:

- Identify all good practices being implemented in the project.
- Identify shortcomings and gaps in implementing comparing to what was planned, or otherwise.
- Offer assistance for improvement and share knowledge gathered from the implementation of good practices at similar projects in the organization or the industry.
- Record contributions from each audit in the lessons learned database of the project.

These auditst accomplish the following:

- Because one of the objectives of a quality audit is to identify inefficient and ineffective policies, processes, and procedures being used for the project, audits reduce the cost of quality on subsequent projects.
- Audits increase customer satisfaction and acceptance of the product or service delivered by the project.

Other Tools

Design for X. Design for X (DfX), also called Design for Excellence, is a set of guidelines of product design. DfX uses a formal methodology to optimize a specific aspect of a design, i.e., X, a variable. Some examples of X are performance, cost, reliability, yield, recycling, safety, quality, assembly, and logistics. The use of DfX in quality management may improve the overall quality, with the performance improvement including cost performance, hence increasing the stakeholders' satisfaction.

Problem Solving. This very general technique, described in Chapter 2, can be used in solving problems arising in audits, such as controlling the quality process and so forth.

Quality Improvement. Some findings and recommendations would come out of managing and controlling quality methods such as auditing and problem solving. Based on those, common quality-improving techniques, such as Six Sigma and Plan-do-check-act, mentioned earlier in this chapter, can be used to analyze and evaluate options for quality improvement.

The work performed during managing quality produces the output discussed in the next section.

Output of Performing Quality Management

The main output of performing quality assurance includes quality reports, test and evaluation documents, and change requests, discussed here:

Quality Reports. Quality reports can include the following:

- Summary findings in the quality control process; e.g.; from quality control measurements
- Recommendation in inspection
- Change requests such as corrective actions recommended for defects and bugs; e.g.; rework or repair
- Recommendation on quality improvement for project, processes, and product
- List of quality management issues escalated by the team

As for the format of the reports, they may be in or include numerical, qualitative, and graphical material.

Change Requests. The goal of quality management is to ensure that the quality requirements are being met, and where they are not, improving quality. For that or any other change by this process, you will have to make change requests, which will be processed by the Perform Integrated Change Control process.

Test and Evaluation. Following the project's industry needs or requirements and the organization's templates, these *test and evaluation documents* are composed for testing and evaluation purposes. They may include checklists and a requirement traceability matrix. These documents are used as an input item by the Control Quality process.

In a nutshell, the Manage Quality process identifies quality problems by comparing quality control measurements against the quality requirements and standards that are planned to be met; examining these problems; making recommendations and change requests to eliminate or fix them; and developing tests and evaluations to be used by the Control Quality process to check or verify they have actually been fixed.

STUDY CHECKPOINT 10.3

Name the processes that will use quality reports as input.

STUDY CHECKPOINT 10.4

Knowing the Manage Quality process, answer the following:

Q1. List the organizational process assets that can influence this process.

Q2. Which component or components of the project management plan, out of the ones listed in the output column of Table 10-3, will need to be modified as a result of quality activities?

Q3. Which component or components of the project management plan, out of the ones listed in output column of Table 10-3, will need to be modified as a result of actual results from project execution?

Tip *Change requests* generated by the Manage Quality process are processed through the Perform Integrated Change Control process, while approved requests are implemented using the Direct and Manage Project Work process, and implementation goes to the Control Quality process in the form of *deliverables* and *work performance data*.

Quality reports will be used by a host of processes; see Study Checkpoint 10.3.

Quality control measurements used as an input in the quality management process come from controlling quality, the process discussed next.

Controlling Quality

Quality is controlled by performing the Quality Control process, which is a high-level process to oversee and control the quality management activities with the goal of ensuring that the project outcome is complete and correct. To that end, the following is accomplished:

1. Verify that all the planned requirements and specifications have been implemented and complied with or conformed to.
2. To be specific, measure the completeness and compliance of the project in its outcome.
3. In these measurements, include all steps, variables, and attributes.

Note The phrase "project outcome is complete and correct" says it all—because it is complete and correct, it has met all the planned requirements and hence meets stakeholders' expectations, and the project outcome does what it was planned to do.

Table 10-4 presents the Control Quality process in terms of input, tools and techniques, and output.

Table 10-4. The Control Quality Process: Input, Tools and Techniques, and Output

Input	Tools and Techniques	Output
1. Project Management Plan: • Quality management plan 2. Project documents: • Test and evaluation documents • Quality metrics • Lessons learned register 3. Approved change requests 4. Work performance data 5. Deliverables 6. Enterprise environmental factors 7. Organizational project assets	1. Data gathering: • Checklists and check sheets • Statistical sampling • Questionnaires and surveys 2. Data analysis: • Root-cause analysis • Performance reviews 3. Data presentation: • Control charts • Cause and effect diagrams • Histograms • Scattered diagrams 4. Test product and evaluation 5. Inspection 6. Meetings	1. Quality control measurements 2. Verified deliverables 3. Work performance information 4. Change requests 5. Project management plan updates: • Quality management plan 6. Project document updates: • Test and evaluation documents • Risk register • Issues log • Lessons learned register

Core of Performing Quality Control Process

The key word in the Control Quality process is *verify*. Performing the Control Quality process can be explained in the following steps in terms of the items from Table 10-4:

1. **Get "How-to" Information.** This process is performed according to the *quality management plan*.

2. **Get What to Verify.** You run verification on *deliverables* and *work performance data* from the Direct and Manage Project Work process. The *work performance data,* discussed in Chapter 3, includes quality schedule and cost quality information, measurements for technical performance, quality metrics, and other quality information such as that from observations.

3. **Verify.** You perform various tasks to run verifications, such as the following:

    - Inspect the deliverables to determine if they conform to the standards as planned, and examine if they meet the acceptance criteria defined in the project scope statement. While doing this, use information from the *work performance data.*

    - Also, use *deliverables* and *work performance data* to verify that *approved change requests* from the Perform Integrated Change Control process are correctly and completely implemented.

    - Run tests from *test and evaluation documents* from the Manage Quality process to check the quality implementation and if various project and product variables comply with the quality specified in the *quality metrics*.

    - Also related to the *test and evaluation documents*, perform evaluations about overall quality objectives' achievement.

4. **Generate Output.** From the information and results obtained from verifications, you can generate the output for this process, such as quality control measurements, verified deliverables, work performance information, and change requests.

Caution! Note that according to PMBOK you are using the project scope statement in the preceding steps, but Table 10-4 also based on PMBOK does not have project scope statement as input.

STUDY CHECKPOINT 10.5

Q1. Which quality process generates quality control measurements?

Q2. Which quality process uses quality control measurements?

Q3. Which quality process generates quality metrics?

Q4. Which quality process uses quality metrics?

To facilitate verification, you can use a plethora of tools and techniques, discussed next.

Tools and Techniques for Quality Control

The tools and techniques used for quality control are explained in the following sections.

Data Gathering

The following techniques can used to collect data for and during verification, e.g.; inspection.

Questionnaires and Surveys. This technique, discussed in Chapter 4, can be used to collect data about customer satisfaction with project outcome.

Statistical Sampling. Statistical sampling involves randomly selecting a part of the population for study. In quality control, you can select a subset of features for inspection, measurements, and quality verification. This can save a substantial amount of resources. To get reasonably accurate results, make sure that the sample is random and of reasonable size; i.e., not too small.

Quality Checklist. A checklist is a structured tool used to verify that a predetermined set of required steps has been performed. The checklists can come in imperative form—e.g.; "to do" lists—or in interrogative form ("have you done this" lists). Checklists are prepared—or identified, if they already exist—in quality planning and used in quality control and are part of input in test and evaluation documents.

Check Sheets. In many data-collection scenarios where you want to put the data in organized form, a very useful tool called check sheets or tally sheets can be used. This tool is particularly suitable when data to be collected is about the variables—e.g.; different errors in a software module. For example, Table 10-5 presents different kinds of errors found in a sample of software modules during inspection.

Table 10-5. Errors Found in Software Modules

Errors / Module Number	1	2	3	4	5	Total
Functionality Errors	5	2	7	0	1	15
Communication Errors	0	1	6	4	1	12
Missing Command Errors	5	0	0	4	1	5
Syntactic Errors	1	7	3	8	2	21
Error-handling Errors	1	1	4	0	0	6
Calculation Errors	0	1	6	4	8	19
Control-flow Errors	7	6	3	0	1	17

Data Analysis

You perform *root-cause analysis*, discussed in the Manage Quality section, to identify the root causes of defects. Also, you can analyze and measure the quality metrics defined in the Plan Quality Management process using the work performance data and compare these measurements with their planned values. This is called the *performance review*.

Data Presentation

In this process, data-presentation techniques are used to identify causes of defects, find the potential effects of quality defects and errors, rank defects and their causes, and find if the processes are stable.

Scatter Diagrams. A scatter diagram is used to show the pattern of the relationship between two variables—an independent variable and another variable that depends on the independent variable. The dependent variable is plotted corresponding to the independent variable. For example, a variable representing a cause, such as temperature, can be the independent variable, and a variable representing the effect, such as operational errors, can be a dependent variable. The closer the data points are to a diagonal line, the stronger the relationship (called the *correlation*) is between the two variables.

So, scatter diagrams can be used to find the causes of defects.

Histograms. In general, a histogram is a representation of the distribution of numerical data. It could be a bar chart that shows a distribution of variables. Each bar can represent an attribute, such as defects due to a specific cause, and its height can represent the frequency of the attribute, such as number of defects. This tool helps rank the defects and causes behind defects, and also ranks the processes in term of numbers or frequency of defect.

You might ask how many defects are acceptable. To find an answer to this question, you need to understand another tool, called the *control chart*.

Control Charts. Control charts, in general, are used to determine if a process is stable—i.e., if its performance can be predicted. In other words, they are used to monitor whether the variance of a specified variable is within the acceptable limits dictated by quality control. A *variance* is a measurable deviation in the value of a project variable, such as cost from a known baseline or expected value. This is a way to monitor the deviations and determine whether the corresponding variable is in or out of control. The values are taken at different times to measure the behavior of a variable over time. The mean value in the control chart represents the expected value, and a predetermined spread from the mean value (usually ±3) is used to define the limits within which an acceptable value can fall.

Control charts can be used to monitor the values of any type of output variables. To illustrate their main features, consider the example of a control chart shown in Figure 10-3. In this example, assume that a manufacturer produces 100 units of a product each day, and it is expected that 95 out of 100 units should have no defect—that is, the expected number of defective units is equal to five. The control limits are set to ±3. In other words, 95 units out of 100 must be correct, give or take three. That puts the lower limit at 92 and the upper limit at 98. Crossing the lower limits is not acceptable to the customer, and crossing the upper limits might require an unjustifiable cost.

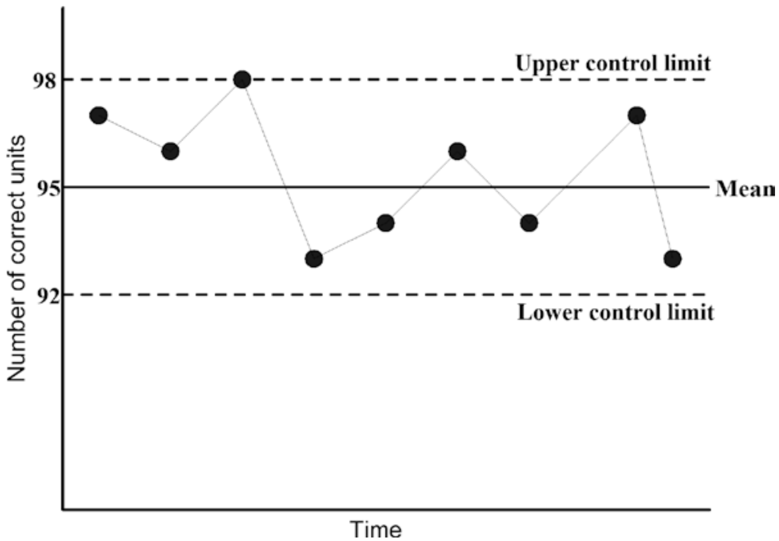

Figure 10-3. An example of a control chart

Controlling quality includes dealing with defects and the problems that cause them. So, studying causes of a problem is critical to quality control.

Caution! The upper and lower limits are based on requirements set in specifications, while control limits are statistically determined from actual data on how the process is performing.

As mentioned earlier, the control charts, in general, are used to determine if a process is stable, and their particular uses can include monitoring the following:

- Volume
- Cost and schedule variance
- Frequency of scope changes

They can also be used for tracking repetitive activities to produce manufacturing lots.

Cause and Effect Diagram. A cause and effect diagram is used to explore all the potential causes (inputs) that result in a single effect (output), such as a problem or a defect. This type of diagram is the brainchild of Kaoru Ishikawa, who pioneered quality management processes in the Kawasaki shipyards, and therefore these diagrams are also called *Ishikawa diagrams*. Due to the shape of these diagrams, they are also known as *fishbone diagrams,* and due to what they do—find multiple causes—they are also called *why-why diagrams*.

For example, to construct and use cause and effect diagrams effectively, you can perform the following simple steps:

1. **Identify the Problem.** Write down the problem in a box drawn on the right side of a large sheet of paper. This represents the head of the fish. Starting from the box, draw a horizontal line across the paper. This represents the spine of the fish.
2. **Identify the Possible Areas of Causes.** Identify the areas or factors from which the potential causes of the problem might come. Environment, people, materials, measurements, and methods are some examples of areas (factors) of causes. For each factor relevant to the problem under study, draw a line off the spine and label it with the name of the factor. These lines represent the fish bones.
3. **Identify the Possible Causes.** For each factor, identify possible causes. Represent each possible cause with a line coming off the bone that represents the corresponding factor.

4. **Analyze the Diagram.** Analyzing the diagram includes narrowing down the most likely causes and investigating them further.

Figure 10-4 shows an example of a cause and effect diagram. The problem in this example is the delay in the release of a website. The factors considered are environment, methods, people, and time. Of course, the diagram is incomplete in the sense that more factors and related causes can be explored, and causes for each factor can be explored further. But you get the point.

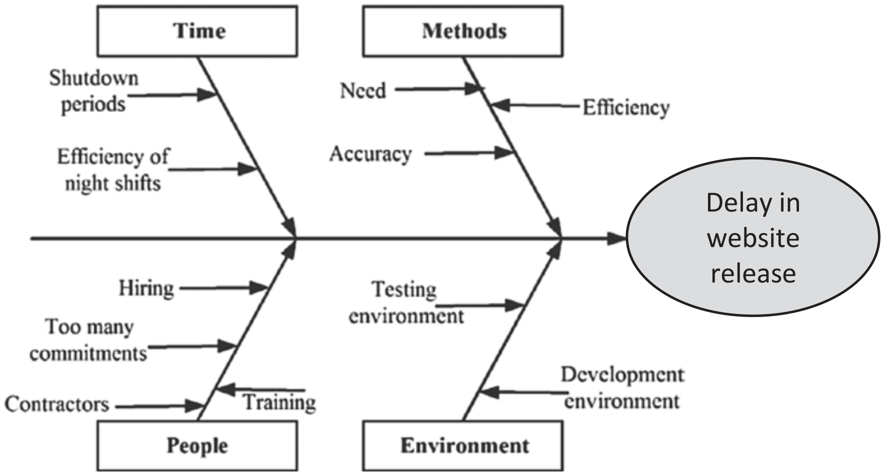

Figure 10-4. An example of a cause and effect diagram: explore the causes for a delay in a website release

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Tip While constructing the cause and effect diagram, you can use the brainstorming method to identify the potential factors of causes and the potential causes for each factor.

A cause and effect diagram offers a structured way to think through all possible causes of a problem. You can use these diagrams to carry out a thorough analysis of a problematic situation. This kind of analysis is useful in complex situations when, to discover the real causes, you need to explore all the potential causes and not just the obvious ones.

In the Manage Quality process, cause and effect diagrams can be used to identify the main or root causes of defects, while in the Control Quality process, they can be used to find the potential effects of quality defects and errors.

In addition to the seven quality tools we have discussed, there are some other tools that you can use for quality control.

Other Quality Control Tools

Two other quality control tools are discussed in the following:

- **Inspection.** This is a technique to examine whether an activity, component, product, service, or result conforms to specific requirements. This can also be used to verify defects and implications to their removal. Inspections can be conducted at various levels of project execution. For example, you can inspect the results of a single activity, or you can inspect the final product of the project, or both. Nevertheless, inspection generally includes measurements. There are various forms of inspections, such as reviews, peer reviews, audits, and walkthroughs.
- **Testing and Product Evaluation.** This technique is used to find bugs, defects, and errors in the product, and also to verify its conformity to quality requirements and standards. Testing does not have to wait until toward the end of project. Rather, it should be performed side-by-side with development. As a product or its component is developed, it can be tested. This approach will be less costly. The kinds of tests depend upon the application areas of the project.

STUDY CHECKPOINT 10.6

Match every item in the first column of the following table to the items in the second column.

Data Presentation Tool	A Use
A. Flowchart	1. To identify the most important area of causes of defects
B. Tally sheets	2. To find the relationship between two variables and find potential causes of defects
C. Scatter diagram	3. To anticipate what quality problems might be and where they might occur
D. Histogram	4. To monitor whether the variance of a specified variable is within the acceptable limits
E. Affinity diagrams	5. To find frequency of defects
F. Control chart	6. To explore all the potential causes of a problem, not just the obvious ones
G. Cause and effect diagram	7. To display the relative importance of different variables, e.g.; its causes

All this works by using these tools to generate the output items for this process, discussed next.

Output of Quality Control

The quality control measurements, verified deliverables, work performance information, and change requests are the main output items of the Control Quality process. These and other output items are discussed in the following list.

Quality Control Measurements. These are the results of the Control Quality activities and are fed back to the Manage Quality process in the form of a document as specified in the quality management plan. They are also used to make recommendations for corrective and preventive actions or other change requests.

Verified Deliverables. These are the deliverables whose correctness and conformity with quality requirements and standards have been verified through the Control Quality process. They are fed into the Validate Scope process discussed in Chapter 4. The rejected deliverables come back to verification after repair.

Work Performance Information. This document from this process includes information about the following items:

- List of verified deliverables
- Causes of rejections
- Status of project requirement fulfilment
- Status of quality metrics
- Recommendations for corrective actions and process adjustments

Change Requests. If in the Control Quality process changes need to occur that affect a component of the project management plan or a project document, you need to generate change requests that must go through the standard process.

Of course, you can have meetings regarding topics relevant to quality control, and you have to make needed modifications to documents such as those listed for modification in the output column of Table 10-4.

STUDY CHECKPOINT 10.7

Match every item in the first column of the following table to the items in the second column. An item in the first column may match with more than one item in the second column and vice versa.

Item	Appears In
A. Quality metrics	1. Input to Plan Quality Management
B. Quality control measurements	2. Input to Plan Quality
C. Quality report	3. Input to Control Quality
D. Test and evaluation documents	4. Output of Plan Quality Management
E. Approved change requests	5. Output of Manage Quality
F. Work performance data	6. Output of Control Quality
G. Deliverables	7. Input to Monitor and Control Project Work
H. Verified deliverables	8. Output of Perform Integrated Change Control
I. Work performance information	9. Output of Direct and Manage Project Work
J. Change requests	10. Monitor and Control Project Work

In a nutshell, the Control Quality process verifies the deliverables and makes quality control measurements by using inspection, data analysis, data presentation, and other techniques to check if quality requirements are met and quality standards are conformed to.

The three most important takeaways from this chapter are as follows:

1. The goal for quality planning is twofold: identify quality requirements and standards for your project and specify how to determine if the process and its product satisfy these requirements and standards.
2. Use the Manage Quality process to verify that the process and its product satisfy these requirements and standards. Incorporate the organization's quality policies and procedures into these activities.
3. In the Monitor Quality process, execute these activities and verify that the project and its deliverables meet the quality requirements and conform to the quality standards. This includes making the quality control measurements based on the actual project performance data.

Summary

Quality management includes planning quality, managing quality, and controlling quality. The quality management plan and quality metrics are the major output items of the quality planning process, called Plan Quality Management. The Manage Quality process identifies quality problems by comparing quality control measurements to the quality requirements and standards that are planned to be met; examines these problems; makes recommendations and change requests to eliminate or fix them; and develops tests and evaluations to be used by the Control Quality process to check or verify they have been actually fixed. The quality control measurements used by the Manage Quality process are made by the Control Quality process based the actual performance data from project execution. This process performs the tests and evaluations developed by the Manage Quality process to verify project deliverables.

Exam's Eye View

Comprehend

- Quality management has two quality components to manage: project quality and project product quality, which is linked to project deliverables.
- Planning quality is all about identifying quality requirements and standards for the project and its deliverables and determining how to test and verify that they have been implemented.
- The Manage Quality process identifies quality problems by comparing quality control measurements against the quality requirements and standards; examines these problems; and makes recommendations and change requests to eliminate or fix them.
- The Manage Quality process also develops tests and evaluations to be used by the Control Quality process to check or verify problems have been actually fixed.
- The Control Quality process verifies the deliverables and makes quality control measurements by using inspection, data analysis, data presentation, and other techniques to check if quality requirements are met and quality standards are conformed to.

Look Out

- Quality is not only about defects in the products; it also includes things like process improvements, completing tasks on time, cost, others aspects of project performance, and so forth.
- Tests and evaluations, an output of the Manage Quality process, can be used by the Control Quality process to verify that quality has been applied.
- Approved change requests are input to the Control Quality process to verify that they are correctly and completely implemented.

Memorize

- The output of the Plan Quality Management process includes *quality metrics* in addition to a quality management plan.
- The Manage Quality process generates *test and evaluation documents* as an output item, which become an input into the Control Quality process.
- The Control Quality process generates *quality control measurements* as an output item, which become an input into the Manage Quality process
- The project charter is used in quality planning.

Review Questions

1. What is the name of a quality-planning technique that involves comparing the results of similar activities?

    A. Brainstorming

    B. Benchmarking

    C. Cost/benefit analysis

    D. Quality metrics

2. What of the following about matrix diagrams is not true?

    A. It is used in planning quality management.

    B. It is used managing quality.

    C. It is used to explore the effects of defects.

    D. It helps to find the key quality metrics important for project success.

3. What of the following about quality metrics is not true?

    A. A metric in quality metrics is a product attribute accompanied by information on how the quality control process will verify its quality conformance.

    B. They are an output of planning quality.

    C. They can be used as a reference or basis for developing a test for quality and for suggesting improvement; e.g.; a change request.

    D. They help to find the key quality metrics important for project success.

4. Which of the following is not an input to the Manage Quality process?

    A. Quality metrics

    B. Quality control measurements

    C. Risk report

    D. Work performance data

5. You are the project manager for the Mind The Gap project. You are going to meet with your project team, where you are going develop quality tests that incorporate the organization's quality policies and procedures. Which of the following processes are you performing?

    A. Quality control

    B. Manage quality

    C. Quality planning

    D. Quality assurance

6. Quality audits are part of which of the following quality management processes?

    A. Manage Quality

    B. Control Quality

    C. Plan Quality Management

    D. Quality Inspection

7. You are the project manager of the Green Schools project. Your supervisor has asked you to make some self-checks and inspections before the stakeholders ask for a formal inspection. It is time to perform which process?

    A. Plan Quality

    B. Perform Quality Control

    C. Perform Quality Assurance

    D. Manage Quality

8. You are using an Ishikawa diagram to find real causes of a problem by exploring all the possible causes. Which one of the quality processes are you performing?

   A. Manage Quality

   B. Plan Quality Management

   C. Control Quality and Perform Quality Assurance

   D. Control Quality

9. You want to examine the results of a process to determine whether the process is in or out of control. Which of the following is the most suitable tool to use?

   A. Control chart

   B. Cause and effect diagram

   C. Inspection

   D. Scatter diagram

10. You are managing a software project with limited development resources. The QA department has discovered a large number of defects in the product, and the project sponsor is very concerned about this. You want to get the maximum number of defects repaired with minimal effort and cost. Which quality-control tool are you going to use before you direct the efforts of the project team to fix specific problems?

    A. Control chart

    B. Cause and effect diagram

    C. Inspection

    D. Scatter diagram

11. You are the project manager for a software development project that has limited resources. The customer is concerned about the quality of the code developed and wants you to conduct the code review. The product contains a large body of code with millions of lines. Which approach will you take?

    A. Tell the customer it's not possible.

    B. Use statistical sampling.

    C. Use automated testing tools.

    D. Arrange to review each line of the code.

12. Which of the following is not an input to controlling quality?
    A. Project deliverables
    B. Work performance measurements
    C. Quality control measurements
    D. Test and evaluation documents
13. Which of the following tools or techniques is not listed in PMBOK to be used in the perform quality control process?
    A. Statistical sampling
    B. Performance reviews
    C. Fishbone diagrams
    D. Change control tools
14. What about flowcharts is not true?
    A. They can be used to understand and estimate the cost of quality for a process.
    B. They can help in improving processes.
    C. They can used to identify points where quality defects may occur.
    D. They help in figuring out the frequency of defects from different attributes of the product during inspection.
15. What about *mind mapping* is not true?
    A. This technique is used in the perform quality assurance process.
    B. This technique may help with figuring out quality requirements.
    C. It can be used to find constraints.
    D. It can help to find relationships such as dependencies.
16. The plan-do-check-act cycle of quality management was:
    A. Defined by Shewhart and modified by Deming.
    B. Originally defined by Deming and then modified by Shewhart.
    C. Defined by Crosby and modified by Deming.
    D. Defined by Crosby and modified by Juan.

CHAPTER

11

Project Risk Management

The objectives covered in this chapter make up 8 percent of the exam, equivalent to about 11 questions. Study the whole chapter in detail.

It's enough to just remember the name of the input, tools and techniques, and outputs. You should know what is in a given input item that the given process uses and how it helps generate the output, as well as what a given tool or technique does in a given process.

You should understand very well how to apply risk tools and methods, such as probability and impact matrix, breakdown structure (RBS), SWOT analysis, root-cause analysis, decision-tree analysis, and EMV analysis. Know how to perform simple risk calculations.

While studying this knowledge area and its processes, pay attention to how the tasks can be adapted to your needs, and also recognize an agile environment in action; e.g.; continual assessment generates change requests, which lead to changing plans—i.e., adapting.

P. Sanghera, *CAPM® in Depth*, https://doi.org/10.1007/978-1-4842-3664-2_11

CAPM Exam Objectives

Project Risk Management:

1. Understand the seven project management processes in the project risk management knowledge area.
2. Identify the input, tools and techniques, and outputs defined in project risk management.
3. Identify the key documents in project risk management.
4. Perform simple risk calculations.
5. Recognize when and how to adjust risk based on the project environment.

Uncertainties are all around us and in our projects. *Risk* refers to an uncertain event or condition that, if it occurs, has a positive or negative effect on meeting the project objectives. After the project starts executing, you will not have enough time to plan a response to a risk if it occurs, so you need to plan the risk responses before the project starts executing. To do that, you need to identify the risks and analyze them. Not all risks are equal. You prioritize the risks based on the analysis and plan responses accordingly, then implement the risk response plan. Also, you need to monitor the risks and their overall management.

So, the core question in this chapter is: how do you manage risks? In search of an answer, we will explore three avenues: planning risk management and planning and executing risk responses; identifying and analyzing risks; and monitoring and controlling risks.

Managing Risks: The Big Picture

To most of us, risk means danger—if it happens, it will result in negative, undesired consequences. However, in project management, a risk is an uncertain event or condition that, if it occurs, has a positive or negative impact on meeting project objectives related to components such as schedule (time), cost, scope, or quality. A negative impact poses a threat while a positive impact offers opportunity. For example, one of the obvious schedule objectives for a project is to complete the project by the scheduled deadline. If a risk related to the schedule occurs, it can delay the completion of the project, or it can make it possible to finish the project earlier. So, the two characteristics of a risk in project management are the following:

- It stems from the elements of uncertainty.
- It might have negative or positive effects on meeting the project objectives.

Risk management includes planning risk management, identifying and analyzing the risks, planning and preparing risk responses, implementing the risk response if the risk occurs, and monitoring the risks. Figure 11-1 shows the corresponding processes used to accomplish these tasks, which are also explained in the following list.

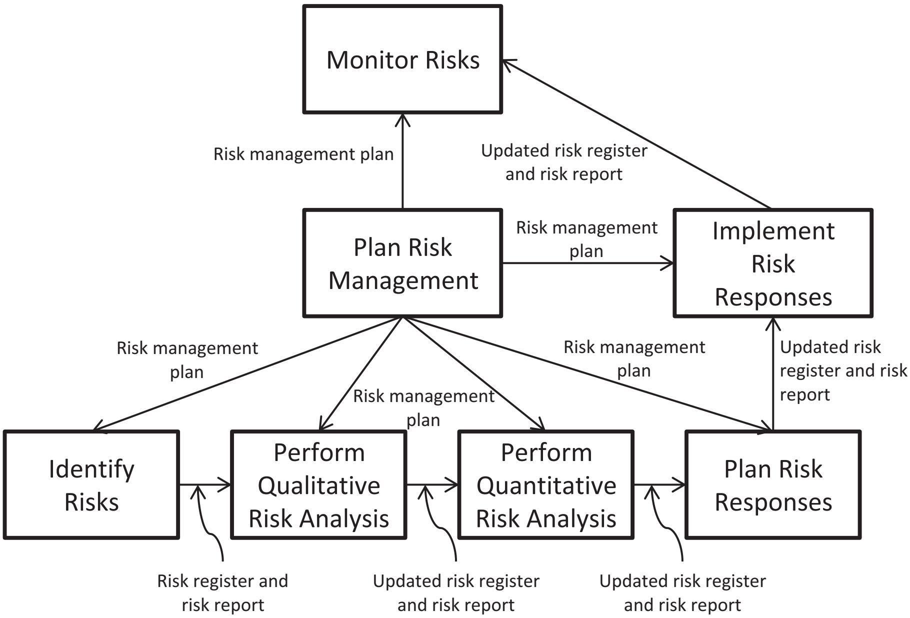

Figure 11-1. Processes used in risk management

- **Plan Risk Management.** A process to determine the HOWs of the risk management: how to conduct risk management for the project at hand; e.g.; what will be the risk management activities and how would they be performed?
- **Identify Risks.** A process to identify and document the risks that might occur for the given project, and also sources of overall project risk.
- **Perform Qualitative Risk Analysis.** A process used for estimating the overall probability of risks occurring and their impact, and for prioritizing them accordingly for further analysis.
- **Perform Quantitative Risk Analysis.** A process used to analyze numerically the effect of identified risks on meeting the project objectives.

- **Plan Risk Responses.** A process used to prepare a risk response plan in order to increase the positive impact and decrease the negative impact of risks on the project.
- **Implement Responses.** The process makes sure that all the planned risk responses are executed as planned.
- **Monitor Risks.** This process is used for tracking identified risks, identifying new risks, and executing and evaluating the effectiveness of risk management processes.

Tip The data flow between the different processes shown in Table 11-1 is true in general. However, note that depending upon the project and the experience of the risk management team, shortcuts can be taken. For example, you can go directly from risk identification to quantitative risk analysis, or even to risk-response planning; or you may need only qualitative risk analysis and not quantitative risk analysis.

These processes are listed in Table 11-1 with the major output from each process.

Table 11-1. Processes of Risk Management Mapped to the Process Groups

Risk Management Process	Process Group	Major Output	Performed
Plan Risk Management	Planning	Risk management plan	Once or at pre-defined points
Identify Risks	Planning	Risk register Risk report	Throughout the project
Perform Qualitative Risk Analysis	Planning	Risk register and risk report updates	Throughout the project
Perform Quantitative Risk Analysis	Planning	Risk register and risk report updates	Throughout the project
Plan Risk Responses	Planning	Risk register and risk report updates	Throughout the project
Implement Risk Responses	Executing	Risk register and risk report updates	Throughout the project
Monitor Risks	Monitoring and Controlling	Work performing information Risk register and risk report updates	Throughout the project

The Implement Risk Responses and Monitor Risks processes are part of the executing process group and the monitor and control process group, respectively, whereas all other risk management processes belong to the planning process group. It's evident that planning risk management demands a considerable effort.

Planning Risk Management

Risk management planning is the process used to determine how the risk management activities for the project at hand will be performed. The major goals for planning risk management are threefold: ensure that the type, level, and visibility of risk management fit with the actual risk involved in the project and the importance of the project to the organization; secure sufficient resources, including time for risk management activities; and set up an agreed-upon basis for evaluating risks. In a nutshell, you use the risk management planning process to determine the following:

- The risk management activities for this project
- How to execute the risk management activities

Table 11-2 presents the Plan Risk Management process in terms of input, tools and techniques, and output.

Table 11-2. The Plan Risk Management Process: Input, Tools and Techniques, and Output

Input	Tools and Techniques	Output
1. Project charter	1. Data Analysis:	1. Risk management plan
2. Project Management Plan:	• Stakeholder analysis	
• Core and all subsidiary plans	2. Expert judgment	
3. Project documents:	3. Meetings	
• Stakeholder register		
4. Enterprise environmental factors		
5. Organizational project assets		

Developing the Risk Management Plan

You perform risk management planning to develop a document called the risk management plan. Take a closer look at the input column of Table 11-2; ignore item 2. We have the *project charter* used to start the project, the *stakeholder register* containing information about project stakeholders, and the project environment in terms of *enterprise environmental factors* and *organizational project assets*. In other words, we have a project, with its environment and

stakeholders, that has just started. Now, add item 2—all the plans from the start to the completion of the project. That is what it takes to manage risks—the whole project. Risks could be anywhere, and you should look for them in all aspects of your projects.

As risk management should initially be planned very early in the project, we need the *project charter* that contains a high-level description of the project and its scope, including boundaries, requirements, and risks. From the project register, you can learn about what roles different stakeholders are playing in the project and what their attitude is toward and relationship is with different types of risks. This will help in planning risk management; i.e., determining risk management roles and responsibilities and the risk threshold by performing *stakeholder analysis* as described in Chapter 8.

The enterprise environment factors relevant to risk planning include the overall risk threshold set by the organizational or key project stakeholders. The organizational project assets relevant to risk planning include organizational risk policy—i.e., approaches toward risk management; definitions of concepts and terms about risk used within the organization; standard risk templates you can use; a roles and responsibilities list; authority levels for decision making; and lessons from similar projects.

You develop the risk management plan by holding planning meetings with relevant stakeholders, such as the following:

- Project manager
- Selected members from the project team
- Selected stakeholders
- Any member from the performing organization who has the responsibility for risk planning and executing

All these efforts generate a document called the risk management plan.

Risk Management Plan

The only output of the Plan Risk Management process is the risk management plan, which includes the following elements.

Strategy and Methodology. The strategy refers to the general approach of handling risks for the project under way, while the methodology specifies the system of approaches, tools, and data sources that will be used to perform risk management on the project at hand. Note that these tools and approaches might vary over the projects, so you have to make the best selection for the given project.

Identifying and Assigning Resources. This identifies the need for resources for risk management, such as human resources, cost, and time:

- **Roles and Responsibilities.** This specifies the roles and responsibilities for each role involved in risk management. These roles are or will be assigned to the members of the risk management team.
- **Funding.** The cost for risk management activities needs to be estimated and included in the budget and the project cost baseline.
- **Timing and Scheduling.** The plan specifies how often the risk management processes will be included in the project schedule, which is planned and developed by using the processes discussed in Chapter 5, "Project Schedule Management." It also specifies what activities will be executed in these risk management processes.

Tip It's a good idea for the risk management team to include members from outside the project team to ensure unbiased risk evaluations.

Stakeholders' Risk Tolerance. For each key stakeholder, the risk tolerance in terms of measurable threshold of objection should be recorded. These threshold values should be taken into account when assessing the priority of individual risks.

Risk Categories. This element, used to facilitate the identification of individual project risks, specifies how risks will be categorized. The risk categories typically correspond to the sources of risks. Depending upon the size and complexity of the project, you might need to develop a risk breakdown structure (RBS), which is a hierarchical structure that breaks the identified risk categories into subcategories. In developing this structure, you will end up identifying various areas and causes of potential risks. The performing organization might already have prepared a categorization of typical risks. However, you need to examine this categorization for each project and tailor it to the needs of the project at hand. The risk categorization helps you identify risks to the extent that you will be identifying various areas and causes of potential risks for your project.

Caution! Some project management literature uses the terms *risk sources* and *risk categories* synonymously; be ready to handle it if happens in the CAPM or PMP exam questions.

Definition of Risk Probability and Impact. Defining different levels of risk probabilities and impacts is necessary to ensure the quality and credibility of the qualitative risk analysis, which we will discuss later in this chapter. The basic issues are defining the scale of likelihood that the risk will happen and defining the scale of the strength of its impact if the risk occurs. These definitions, even if they already exist in the organization, must be examined and tailored to the needs of the specific project. In qualitative analysis, we are talking about relative impact levels.

As an example, Table 11-3 shows the risk impact definitions for four project objectives: cost, quality, scope, and time. Note that this example only shows the negative impact. The heading of the table presents the impact scale, and each cell in the following rows from column 2 to column 6 specifies the impact on a specific objective corresponding to a point on the overall impact scale. For example, the cell corresponding to the first row and fifth column reads that high impact (0.65) means a 50 to 80% increase in cost.

Table 11-3. Risk Impact Definitions for Four Project Objectives

Risk Impact/ Project Objectives	Very Low (0.05)	Low (0.10)	Moderate (0.35)	High (0.65)	Very High (0.90)
Cost	Less than 1% cost increase	1–20% cost increase	20–50% cost increase	50-80% cost increase	80-100% cost increase
Time	Insignificant time increase	1–10% time increase	10–30% time increase	30–60% time increase	60–100% time increase
Scope	Scope decrease unnoticeable	Scope of only a few minor areas affected	Sponsor approval necessary for scope reduction	Scope reduction unacceptable to the sponsor	Project and item are effectively useless
Quality	Unnoticeable quality reduction	Only a few applications will be affected	Quality requires sponsor approval	Quality reduction unacceptable	Project and item are effectively useless

You can define the risk probability scale from very unlikely to almost certainly, called the *relative scale*. As an alternative, you can define a numerical scale in which the probability is represented by numbers, in which case a value close to 0.0 means very unlikely and a value close to 1.0 means almost certainly. The impact scale represents the size of the risk impact on the given project objective should the risk occur. Just like the probability scale, you can define

the impact scale relatively or numerically. The relative scale can range from very low impact to very high impact, with points in the middle such as low, moderate, and high. As an alternative, you can define the impact numerically; it might be linear, such as the first point at 0.1, the second point at 0.2, and the tenth point at 1.0, or it might be nonlinear, such as the first point at 0.001, the second point at 0.01, and the third point at 0.1.

Probability and Impact Matrix. Risks are prioritized according to the values of probabilities of risk occurrences and the sizes of their impacts on the project objectives as estimated; e.g.; a qualitative analysis. The values are recorded in what is called a probability–impact matrix. For a given risk, its priority is determined by comparing its value in this probability–impact matrix with the value in the reference probability–impact matrix used as a *lookup table*. Even if your organization already has this reference matrix, you should examine it and tailor it to the needs of the specific project. I will discuss the probability and impact matrix in more detail later in this chapter.

Risk Reporting and Tracking. The risk reporting part of the risk management plan describes what kind of content and in what format each output of the risk processes—e.g.; risk register and risk report—will be. This about how to document the output of the risk management processes. It may also include how these outputs will be communicated.

Risk tracking describes how each risk management process used in the project would be audited. Obviously, should the performing organization decide to audit the risk management process, one should be able to track these activities.

During the process of planning risk management for a specific project, you revisit the tolerance levels of the stakeholders for certain risks, and these levels may be revised. So, risk management planning is the process that generates the risk management plan document, which contains the information that will be used in risk identification, risk analysis, and responding to risks.

You cannot manage a risk if it's not identified.

Identifying Risks

Risks are identified by using the risk identification process. An unidentified risk is a danger lurking out of your sight and waiting to attack the project. The significance of the risk identification process cannot be overemphasized. You use the risk identification process to accomplish the following tasks:

- Identify the individual risks that might affect the project at hand, and also identify the overall sources of project risks.
- Document the characteristics and other information about the identified risks in a document called the *risk register*.

Table 11-4 presents the Identify Risks process in terms of input, tools and techniques, and output.

Table 11-4. The Identify Risks Process: Input, Tools and Techniques, and Output

Input	Tools and Techniques	Output
1. Project Management Plan: • Risk management plan • Requirement management plan • Schedule management plan • Cost management plan • Quality management plan • Resource management plan • Scope baseline • Schedule baseline • Cost baseline 2. Project documents: • Cost and duration estimates for project activities • Requirement documentation • Resource requirement • Assumptions log • Issues log • Stakeholder register • Lessons learned register 3. Agreements 4. Procurement documentation 5. Enterprise environmental factors 6. Organizational project assets	1. Data Gathering: • Checklists • Interviews • Brainstorming 2. Data Analysis: • Document analysis • Root-cause analysis • Assumption and constraint analysis • SWOT analysis 3. Interpersonal and team skills: Facilitation 4. Prompt lists 5. Expert judgment 6. Meetings	1. Risk register 2. Risk report 3. Project document updates: • Assumptions log • Issues log • Lessons learned register

We can use the items in this table to perform the Identify Risks process.

Performing Risk Identification

Remember, the goal of this process is to identify the individual project risks and overall sources of project risks. The risk management plan will give basic guidance on how to perform this process for your project, while here we will discuss in general how to do it. As the long list of input items in Table 11-4 indicates, risks are hiding in almost all areas of the project. The key to finding them lies in the uncertainty coming from various sources; e.g.; assumptions, ambiguity, estimates, ranges as uncertainty gives rise to risks.

So, as a starting point in identifying risks, look for areas of assumptions, ambiguities, and estimates in agreements, procurement documentation, and project documents and plans listed in Table 11-4. For example, *cost and duration estimates* for project activities and the *assumptions log* are obvious places to start. You can use *document analysis*, discussed in Chapter 4 and other places in the book, on these input documents to identify individual project risks. Furthermore, the knowledge database related to risk management from previous projects can also be reviewed with this technique.

To identify the individual project risks and overall sources of project risks, you can also use the other tools and techniques listed in Table 11-4, as discussed next.

Data-Gathering Techniques

To identify risks and project risk sources, you need to gather risk-related information from a variety of sources. The following are some of the information-gathering techniques used for this purpose.

Checklists. A checklist is a kind of to-do list—a list of actions to be taken or points to be considered. They can be used as a tool in this process, such as a checklist of all the documents that must be looked at for risks. The carefully prepared checklists in any process are great no-brainer timesavers. Projects in the same organization will more often than not have similarities. As a result, you can develop a risk identification checklist based on the information gathered from a similar set of projects previously performed. Also, if you developed the risk breakdown structure (RBS) in risk planning, the lowest level of RBS can often be used as a checklist, which could be the list of risk categories.

Note Risk identification checklists are rarely exhaustive. Always explore what is left out of the checklist you are using. Also, make sure the checklist is up-to-date when you close the project to enhance its value for future projects.

Interviewing. This is one of the common methods used for information gathering for risk identification. You interview the appropriate stakeholders and subject-matter experts to gather information that will help identify risks for the project at hand.

You can then conduct a brainstorming session based on the information gathered.

Brainstorming. This technique, defined in Chapters 3 and 4, can be used to identify risks and risk sources. The goal here is to get a comprehensive list of potential risks so that no risk goes unidentified. The project team, along

with the relevant experts from different disciplines, can participate in the brainstorming session. Brainstorming is better performed under the guidance of a facilitator. You can use the categories of risks or the RBS as a framework to keep the session focused on the issue.

When you have gathered the risk-related data, you can analyze it to identify the individual project risks and overall sources of project risks.

Data-Analysis Techniques

The data-analysis techniques used to identify the individual project risks and overall sources of project risks may include those in the following sections.

Assumption and Constraint Analysis. Assumptions in the project, by definition, represent uncertainty—hence, risk. You analyze these assumptions to identify the risks. Assumption and constraint analysis is the technique used to examine the validity of assumptions and constraints and thereby to identify the risks resulting from the inaccuracies, inconsistencies, or incompleteness of each assumption. For example, assume that there is only one person in the organization who has a rare skill needed for the project. An obvious assumption would be that the person will not quit the organization before completing the assignment. The likelihood of this assumption being false—i.e., the inaccuracy of this assumption—amounts to the risk. Constraints, by their limiting factor, also create uncertainty, hence, risk.

Root-cause Analysis. Discussed in Chapter 10, root-cause analysis is a powerful way to identify new risks by identifying the root cause of known risks. After you spot a potential cause for risks, it's simple to identify the risks resulting from that cause. Furthermore, knowing the cause of a risk helps you plan an effective response. In this technique, you obviously end up identifying the sources, or causes, of project risks.

You can also look for risks by starting from the impacts of risks.

SWOT Analysis. While the root-cause analysis technique looks into the causes of the risks to identify the risks, a SWOT analysis looks at the potential impacts of the risks to identify the risks. If you examine the strengths, weaknesses, opportunities, and threats (SWOT) of a given project, you will be exposing the risks involved. Remember that a strength is an opportunity, a weakness is a threat, and opportunities and threats are posed by risks. This helps broaden the spectrum of risks considered. For example, a strength of your project might be that most of its parts are well understood from previously executed similar projects. Therefore, the risks involved in those parts will be easy to identify. A weakness of your project might be that one of the parts involves new technology that is not well tested. So, this is a source of unknown risks. An opportunity might be that your organization will be the first one to take this product to the market. An example of a threat might be that the government is considering a bill that, if it becomes a law, will have profound implications for your project.

■ **Note** *Prompt Lists*. A prompt list is a predetermined list of risk categories that can be used to generate ideas to identify individual project risks and also acts as the lowest level in the risk breakdown structure (RBS).

Of course, you can always use the judgment of experts on the topic. You will generally be using more than one of these tools and techniques to identify risks. During risk identification, you might discover the causes of the risks, and you might even think of some potential risk responses. All this is part of the output of the risk identification process.

The Output of Risk Identification

Two documents, risk register and quality report, are initiated with the results of the Identify Risks process and are completed by other risk management processes.

Risk Register

The risk register is a document that contains the risk output of the risk identification process; i.e., information about the individual project risks. You will see later in this chapter that the risk register, which is initiated in the risk identification process, will also contain information or results from other risk management processes. To begin, you store the following information from the risk identification process in the risk register:

- **List of Identified Risks.** These are the individual risks that you identified in the risk identification process, each risk with a unique ID. These risks should be described in reasonable detail, which may include the following:
  - **The Risks.** The definition and nature of each risk itself and the causes that will give rise to that risk.
  - **List of the Root Causes of the Risks.** This is a list of events or conditions that might give rise to the identified risks.
  - **Updates to Risk Categories.** Risk categories were originally identified in the risk management planning process. However, in the process of identifying risks you might discover new categories or modify existing categories. The updated risk categories must be included in the risk register.

- **Risk Owner.** Each risk must be assigned an owner. If not identified yet, it will be in the Perform Qualitative Risk Analysis process. If the owner is known, it should be confirmed during the Perform Qualitative Risk Analysis process.

- **List of Potential Responses.** Risk-response planning is a separate process that is performed after risk analysis. However, during risk identification, you might identify potential risk responses that you must document in the risk register. These responses can be further examined and planned in the risk-response planning process.

Risk Report

From this process, the risk report has 1) information about sources of overall project risks, answering the question: what are the main risk drivers for this project? and 2) summary of individual project risks stating their distribution across the risk categories, threats and opportunities that they present, their impact, and trends resulting from them. Some results from other risk management processes are added to this report.

STUDY CHECKPOINT 11.1

Problem: Knowing the Identify Risks process, make lists of some EEFs and OPAs that can influence this process.

The results of the risk identification process usually lead to qualitative risk analysis. However, depending upon the project and the experience of the risk management team, risk identification might lead directly to quantitative risk analysis and even to risk-response planning.

Analyzing Risks

Once the risks have been identified, you need to answer two main questions for each identified risk: what are the odds that the risk will occur and, if it does, what will its impact be on the project objectives? You get the answers by performing risk analysis, which comes in two forms: qualitative and quantitative:

- **Perform Qualitative Risk Analysis.** This is used to prioritize the identified individual project risks by estimating the probability of their occurrence, their impact on the project objectives, and other risk factors.

- **Perform Quantitative Risk Analysis.** This is used to perform numerical analysis to estimate the combined effect of identified individual project risks and other uncertainty sources on the overall project objectives.

Usually, you prioritize the risks by performing qualitative analysis on them before you perform quantitative analysis.

Qualitative Risk Analysis

Because qualitative analysis is an estimate, it is less precise than the quantitative analysis, which is based on numbers from detailed analysis. However, qualitative analysis is quicker and cheaper. It gives you some feel about the risks, and then you can determine which risks need to be analyzed further by using quantitative analysis.

Table 11-5 presents the qualitative risk analysis process in terms of input, tools and techniques, and output.

Table 11-5. The Perform Qualitative Risk Analysis Process: Input, Tools and Techniques, and Output

Input	Tools and Techniques	Output
1. Project Management Plan: • Risk management plan 2. Project documents: • Risk register • Assumptions log • Stakeholder register 3. Enterprise environmental factors 4. Organizational project assets	1. Data Gathering: • Interviews 2. Data Analysis: • Assessments of risk data • Assessments of risk probability and impact • Assessments of other risk parameters 3. Data Presentation: • Probability and impact matrix • Heterarchical charts 4. Categorization of risks 5. Interpersonal and team skills: Facilitation 6. Expert judgment 7. Meetings	1. Project document updates: • Risk register • Risk report • Assumptions log • Issues log

Table 11-5 shows the input, tools and techniques, and output for qualitative analysis, which are discussed in the following sections.

We can use the items in this table in the Perform Qualitative Risk Analysis process.

Performing Qualitative Risk Analysis

Recall that the goal of this process is to prioritize risks by estimating the probability of their occurrence, their impact on the project, and other risk factors. To do that, you need information from items in the input column of Table 11-5. For example, the risks that need to be prioritized are in the *risk register* along with information about them. The information about assumptions and constraints in the *assumptions log* will help prioritize the risks, and information about stakeholders in the *stakeholder register* will help assign the owners of each risk.

"How-to" information for qualitative risk analysis can be obtained from the *risk management plan*, which also contains other useful information for this process, such as the following:

- Roles and responsibilities for performing risk management
- Budgeting for risk management
- Definitions of probabilities and impacts
- The probability and impact matrices
- Risk categories
- Risk timing and scheduling
- Stakeholders' risk tolerances

If any of these input items was not developed during risk management planning, it can be developed during this process.

With this information at hand, you use tools and techniques to generate the output of this process.

Tools and Techniques for Qualitative Risk Analysis

Prioritizing risks based on their probability of occurrence and their impact if they do occur is the central goal of qualitative risk analysis. Accordingly, most of the tools and techniques used involve estimating probability and impact.

Assessment of the Risk Data Quality. Qualitative risk analysis is performed to analyze risk data in order to prioritize risks. However, before you do this, you must examine the risk data for its quality, which is crucial because the credibility of the results of qualitative risk analysis depends upon the quality of the risk data. If the quality of the risk data is poor, you might decide to gather better-quality data. The technique to assess the risk data quality involves examining the accuracy, reliability, and integrity of the data and also examining how good that data is relevant to the specific risk and project for which it is being used. Biases and attitudes of the data sources—e.g.; peoples—must be collected and used as a corrective factor applied to the raw data to improve its quality.

Assessment of Risk Probability and Impact. Risk probability refers to the likelihood that a risk will occur, and impact refers to the effect the risk will have on a project objective if it occurs. The probability for each risk and its impact on each project objective, such as cost, quality, scope, and time, must be assessed. The definitions of probability and impact used in this assessment come from the risk management plan. Note that probability and impact are assessed for each identified risk.

Methods used in making the probability and impact assessments include holding meetings, interviewing, considering expert judgment, and using an information database from previous projects. The assessed levels of probability and impact for each risk are recorded with the assumptions made in assessing. To prioritize the risks, you need to look at both probability and impact.

Caution! Remember, the impact can be negative, posing a threat, or positive, representing an opportunity. Also, a risk with a high probability might have a very low impact, and a risk with a low probability might have a very high impact, and vice versa.

Assessments of Other Risk Parameters. In addition to probability and impact, you may consider other risk factors in prioritizing risks, such as risk urgency; manageability, i.e., ease of managing risk; controllability, i.e., how much the risk owner is able to control the risk's output; and connectivity, i.e., how many other risks this risk is connected to. For example, a risk that is going to occur now is more urgent to address than a risk that might occur a month from now. Similarly, the higher the value of the mentioned factor, such as controllability, the higher the risk priority is.

Probability and Impact Matrix. Risks need to be prioritized for entries into quantitative analysis, response planning, or both. The prioritization can be performed by using the probability and impact matrix—a lookup table that can be used to rate a risk based on where it falls both on the probability

scale and on the impact scale, combined. There are multiple ways of forming a probability and impact matrix and determining the risk priority, such as the following:

- You can separate probability and impact matrix for each project objective.
- Determine the priority for each risk by:
    a. Combining the impact of a given risk on each objective; e.g.; weighted average
    b. Taking the highest value of impact on any objective as the final overall value

Table 11-6 presents an example of a probability and impact matrix by showing both the probability scale and the impact scale. Here is an example of how to read this matrix: risk R_{45} has a probability of 0.70 (that is, seven out of 10 chances) for occurrence and an impact of 0.45 on the project objective for which this matrix is prepared. How to calculate the numerical scales for the probability and impact matrix and what they mean depends upon the project and the organization, and they must be defined in the risk management plan. However, remember the relative meaning: higher value of a risk on the probability scale means a greater likelihood of risk occurrence, and a higher value on the impact scale means a greater effect on the project objective should the risk occur. The higher the value for a risk, the higher its priority is. For example, risk R_{38} a has higher priority level than risk R_{23}.

Note By priority value, in this discussion, we mean the priority level, as in qualitative analysis we are interested only in relative level. However, each risk cell in Table 11-6, e.g.; R_{14}, can have a value computed from corresponding values of probability and impact using the formula given in the risk management plan.

Table 11-6. A Risk Probability and Impact Matrix for an Objective*

Probability	**Impact**								
0.00	0.05	0.15	0.25	0.35	0.45	0.55	0.65	0.75	0.90
0.10	R_{11}	R_{12}	R_{13}	R_{14}	R_{15}	R_{16}	R_{17}	R_{18}	R_{19}
0.30	R_{21}	R_{22}	R_{23}	R_{24}	R_{25}	R_{26}	R_{27}	R_{28}	R_{29}
0.50	R_{31}	R_{32}	R_{33}	R_{34}	R_{35}	R_{36}	R_{37}	R_{38}	R_{39}
0.70	R_{41}	R_{42}	R_{43}	R_{44}	R_{45}	R_{46}	R_{47}	R_{48}	R_{49}
0.90	R_{51}	R_{52}	R_{53}	R_{54}	R_{55}	R_{56}	R_{57}	R_{58}	R_{59}

* *R_{ij}, where i and j are integers, represent risks in the two-dimensional (probability and impact) space.*

According to the scheme in Table 11-6, each risk is rated (prioritized) based on the probability and the impact value assigned to it separately for each objective. Generally, you can divide the matrix in Table 11-6 into multiple areas; e.g.; three areas—high-priority risks represented by higher numbers, such as R_{59}, medium-priority risks represented by moderate numbers, such as R_{23}, and low-priority risks represented by lower numbers, such as R_{12}. However, each organization has to design its own risk score and risk threshold to guide the risk response plan.

Note that impact can be a threat (a negative effect) or an opportunity (a positive effect). The same matrices will be used for both threats and opportunities, but the interpretation will be different. Threats in the high-priority area might require priority actions and aggressive responses. Also, you will want to capitalize on those opportunities in the high-priority area, which you can do with relatively little effort. Risks posing threats in the low-priority area might not need any response, but they must be kept on the watch list.

Hierarchical Charts. For assessments of risk priority, when you use not just probability and impact, but more than two parameters, then a two-dimensional probability–impact matrix, a table, would be enough. You will use multidimensional graphical techniques to assess priority for individual risks. For example, for two parameters in addition to impact, you can represent the values of the two parameters using the x and y axes, and the *impact* values can be expressed by the size of the data symbol representing the values of the two parameters. One such plot, where disk symbols represent data points, is called a bubble chart. All the multidimensional charts used to assess risk priority are collectively called hierarchical charts.

Risk Categorization. You defined the risk categories during risk management planning and the risk identification processes. Now, you can assign the identified risks to those categories. Because you now have more information about risks for the project, you can also revisit the categorization schemes—categorization by risk sources such as RBS, by risk-affected project areas such as WBS, or by root causes. Categorizing risks by their causes often helps you develop effective risk responses.

Expert Judgment. You may need expert judgment to assess the probability and impact of each risk. To find a person with expertise, look for people who have experience with similar projects in the not too distant past. While weighing the expert judgments, look for possible biases. Often, experts are biased for their area against other areas.

Of course, you will be using meetings in this process.

You need to update the risk register and risk report with the result of the qualitative risk analysis.

Output of the Qualitative Risk Analysis

The output of the qualitative risk analysis is as follows.

Updated Risk Register

The risk register was initiated during the Identify Risks process and is updated with the new information or results from the qualitative risk analysis. The updates include the following:

- **Probability, Impact, and Priority.** Each individual risk is assigned an assessment for probability, impact, and priority of risk as estimated in this process.
- **Owner.** Each individual risk is assigned an owner.
- **Risk Urgency Information.**
- **Risk Categorizations.** This means making sure every category has information assigned to it. This helps in various ways; for example, you can identify the common root causes of the risks and the areas of the project that might require special attention. Furthermore, categorizing risks can bring order to a chaotic situation and makes the management of these risks easier and more effective.
- **List of Risks.** Using some criteria, you can make different lists of risks for effective management. The following are some examples:
    - **Further Analysis.** List of risks for additional analysis and response, such as quantitative analysis.
    - **Watch List of Low-priority Risks.** This list contains the risks that are deemed unimportant by the qualitative risk analysis but that need to be monitored continually.
    - **List of Risks with Time Urgency.** This list includes urgent risks that require attention now or in the near future.

Tip *Trends in the Analysis Results.* By examining the results from the qualitative risk analysis, you might recognize a trend for specific risks. That trend might suggest further analysis or a specific risk response.

Updated Risk Report

The risk report is updated with the following information:

- A list of the most important individual project risks; e.g.; risks at the top of the priority list based on the probability and impact matrix discussed earlier in this chapter.
- Priority list of all identified risks in the project
- Summary conclusion

The *assumptions log* will be updated with new assumptions made or found in this process or old assumptions that have changed, and the *issues log* will be updated with the addition of new issues or changes in the existing issues.

The main result of qualitative risk analysis is the prioritization of risks based on a probability and impact matrix for each objective. So, each objective can have its own prioritized list of risks.

Qualitative risk analysis is a relatively quick and cost-effective way to prioritize risks for risk planning. It also does the groundwork for the quantitative risk analysis if one is required for some risks, as noted in the risk register.

Quantitative Risk Analysis

Quantitative risk analysis is generally performed on the risks that have been prioritized using qualitative risk analysis. However, depending upon the experience of the team and their familiarity with risk, it is possible to skip qualitative risk analysis and move directly, after risk identification, to quantitative risk analysis. The quantitative risk analysis has three major goals:

- Assess the probability of achieving specific project objectives.
- Quantify the aggregated effect of the individual risks and other uncertainty sources on the overall project objectives.
- Prioritize risks by their contributions to the overall project risk.

Table 11-7 presents the Quantitative Risk Analysis process in terms of input, tools and techniques, and output.

We can use the items in this table to perform the Quantitative Risk Analysis process.

Table 11-7. The Quantitative Risk Analysis Process: Input, Tools and Techniques, and Output

Input	Tools and Techniques	Output
1. Project Management Plan: • Risk management plan • Scope baseline • Schedule baseline • Cost baseline 2. Project documents: • Risk register • Risk report • Resource requirements • Schedule forecast • Milestones list • Duration estimate • Cost forecast • Cost estimates • Basis of estimate • Assumptions log 3. Enterprise environmental factors 4. Organizational project assets	1. Data Gathering: • Interviews 2. Representations of uncertainty 3. Data Analysis: • Simulations • Sensitivity analysis • Decision-tree analysis • Influence diagrams 5. Interpersonal and team skills: Facilitation 6. Expert judgment	1. Risk report update

Performing Quantitative Analysis

The fact that most of the input items for this process are related to project scope, schedule, and cost, the three fundamental components constituting the project base, is a reflection of the fact that risks can affect all aspects of the project. These input items also hold information about three key items that we need to start performing the quantitative risk analysis: individual project risk, reference points to measure the effect of individual risks, and reference points to measure the variability—i.e., uncertainty—as is explained next. In light of this, performing the Quantitative Risk Analysis process may be explained in the following steps in terms of the items from Table 11-7:

1. **Get Risk and "How-to" Information.** The "how-to" information about this is in the *risk management plan*, which also explains the resources, or analysis tools, to use and how often the process should be run. The needed information about individual project risks and about the sources of overall project risk can be found in the *risk register* and *risk report*, respectively.

2. **Get Information about Reference Points to Measure the Effect of Individual Risks.** The reference points, or starting points, as the PMBOK 6th Edition calls it, refers to the planned values (e.g.; $700 to build a component), and the effect of the related individual risk is deviation from the planned values (e.g.; $100 more if the risk occurs). Information about these reference points can be obtained from the *cost baseline*. Information about other reference points can be obtained from other inputs: *scope baseline* and *schedule baseline*.
3. **Get Information about Reference Points to Measure the Variability.** Even before or without any individual project risk occurrence, the project has built-in uncertainties in the form of estimates. Therefore, the deviation or variability should be measured in reference to these built-in uncertainties. Information about these reference points to measure variability can be obtained from *cost estimates*, *duration estimate,* and *resource requirements*. Also, uncertainties due to the *basis of estimate* and relevant entries in the *assumptions log* should be modeled in the quantitative analysis.
4. **Check the Result of Quantitative Analysis.** When you use statistical methods in an analysis, there should always be a way to determine how believable the result from the analysis is; i.e., the confidence level. In our case, we can determine the confidence level by comparing the different parts of the analysis results against information from the targets in the *milestones list* and *schedule forecast*, and values of quantities predicted in the *cost forecast*: BAC, EAC, ETC, TCPI, etc., covered in Chapter 7.
5. **Model the Individual Project Risks Effects and Other Uncertainty Sources.** In steps 2 and 3 we discussed measuring the effect of individual project risks on project objectives such as cost and schedule as well as other uncertainty sources, such as assumptions, basis of estimates, and estimates. For quantitative analysis, we model uncertainty as probability distributions. The effects of individual project risks may be included in these distributions or can be modeled separately as probability branches.

With this information in hand, you can use various tools and techniques to generate the results of quantitative risk analysis.

Tools and Techniques for Quantitative Analysis

The quantitative risk analysis can be looked upon as a two-step process—gathering and representing the data, and analyzing and modeling the data. Accordingly, all the techniques fall into two categories: data gathering and representation techniques, such as interviewing, probability distributions, and expert judgment; and analysis and modeling techniques, such as sensitivity analysis, EMV analysis, decision-tree analysis, and modeling and simulation.

Interviewing. This technique is used to collect the data for assessing the probability of achieving specific project objectives. You are looking for results such as: We have a 70 percent probability of finishing the project within the schedule desired by the customer. Or perhaps: We have a 60 percent probability of finishing the project within the budget of $100,000. The goal is to determine the scale of probabilities for a given objective; for example, there is a 20 percent probability that the project will cost $50,000, a 60 percent probability that it will cost $100,000, and a 20 percent probability that it will cost $150,000.

The data is collected by interviewing relevant stakeholders and subject-matter experts. Most commonly, you will be exploring the optimistic (best-case), pessimistic (worst-case), and most-likely scenarios for a given objective. For example, for the project cost, the optimistic estimate might be $10 million, the pessimistic estimate might be $50 million, and the most-likely estimate might be $25 million.

Representation of Uncertainty: Probability Distributions. The risks and uncertainty in the input to the quantitative risk analysis, discussed in the previous section, need to be modeled. In step 5 of the previous section, we discussed that uncertainty can be modeled as probability distributions, and the effects of individual project risks may be included in these distributions or can be modeled separately as probability branches. The data on meeting the project objectives can be presented in a probability distribution for each objective under study. Note that, by definition, a distribution represents uncertainty, and a risk also represents uncertainty, or vice versa. For example, if you know for sure the project will cost $25 million, there will be no distribution because it is only one data point.

Probability distribution comes into the picture when you have several possible values with a probability assigned to each value. There are distributions of different shapes in which the data can be presented. The commonly used distributions, according to PMBOK Edition 6, are uniform, beta, triangular, normal, lognormal, and discrete distributions. The uniform distribution is used when all the values of an objective have the same chance of being true. Figure 11-2 shows some of them for the cost objective. The x-axis represents the cost, and the y-axis represents the corresponding probability that the project will be completed within that cost.

We do all this modeling for analysis.

Sensitivity Analysis. This is a technique used to determine which individual risks and other sources of uncertainty have the greatest impact on the project outcomes. Just for the sake of understanding, imagine you study the impact

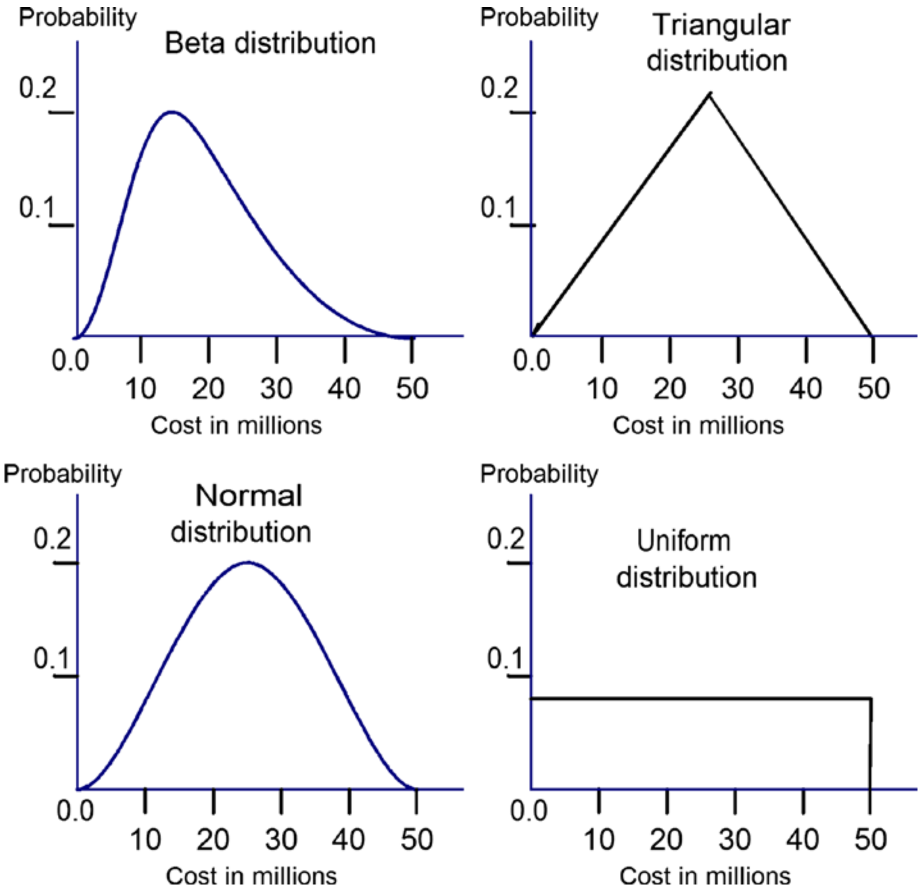

Figure 11-2. Examples of probability distributions commonly used in quantitative risk analysis

of one risk or uncertain element on a project objective by keeping all other uncertain elements fixed at their baseline values. You can repeat this analysis for several objectives, one at a time. You can also repeat this study for several uncertain elements (creating risks) one element at a time. This way, you can see the impact of each element (or risk) on the overall project separate from other elements (or risks).

Practically, you will be using a software package to run this analysis. The strength of impact is measured by investigating the correlation of the variation in project outcome with the variations in different elements of the analysis model; e.g.; various risks and other uncertainty sources. A higher value of the correlation coefficient of an element indicates a higher impact of that element in the project outcome. The analysis may generate plots of correlation coefficients of elements—e.g.; a tornado diagram, which has one bar for each element with non-zero impacts on project outcome along the x-axis, with the height of the bar along the y-axis representing the value of the correlation coefficient for that element.

Modeling and Simulation. A *model* is a set of rules to describe how something works; it takes input and makes predictions as output. The rules might include formulas and functions based on facts, assumptions, or both. A *simulation* is any analytical method used to imitate a real-life system. Simulations in risk analysis are created using the Monte Carlo technique, which is named after Monte Carlo, Monaco—known for its casinos that present games of chance that are based on random behavior. Monte Carlo simulation models take random input iteratively to generate output for certain quantities as predictions. This technique is used in several disciplines, such as physics and biology, in addition to project management.

In risk analysis, Monte Carlo is used to simulate the combined effect of identified individual project risks and other uncertainty sources on project outcomes to see their impact on meeting the various project objectives. The input is taken randomly from a probability distribution—e.g.; about cost and duration estimates—and the output for impact on the project objectives is predicted. The name "Monte Carlo" refers to the random behavior of the input. (In that spirit, it could easily be called "Las Vegas.")

Tip *S-curve:* Simulation analysis can generate cumulative probability diagrams, called S-curve, in which the x-axis represents the predicted value of a project variable such as cost, while the y-axis represents the cumulative probability for the predicted values.

As already mentioned, the effects of individual project risks may be included in these distributions or can be modeled separately as probability branches. We now will discuss probability branches, for which you need to understand the concept of expected monetary value.

Expected Monetary Value Analysis. Expected monetary value (EMV) analysis is used to calculate the expected value of an outcome when different possible scenarios exist for different values of the outcome with some probabilities assigned to them. The goal here is to calculate the expected final result of a probabilistic situation. EMV is calculated by multiplying the value

of each possible outcome by the probability of its occurrence and adding the results. For example, if there is 60 percent probability that an opportunity will earn you $1,000 and a 40 percent probability that it will only earn you $500, the EMV is calculated as follows:

$$\text{EMV} = 0.60 \times 1000 + 0.40 \times 500 = 600 + 200 = 800$$

So, the EMV in this case is $800. When you are using opportunities and threats in the same calculation, you should express EMV for an opportunity as a positive value, and that for a threat as a negative value. For example, if there is 60 percent chance that you will benefit from a risk by $1000, and 40 percent probability that you will lose $400 as a result of this risk, the EMV is calculated as follows:

$$\text{EMV} = 0.60 \times 1000 - 0.40 \times 500 = 600 - 200 = 400$$

Therefore, the EMV in this case is $400.

The concept of EMV can be presented in a decision-making technique, such as a decision-tree analysis.

Decision-tree Analysis. This technique uses the decision-tree diagram to choose from different available options; each option is represented by a branch of the tree. This technique is used when there are multiple possible outcomes with different threats or opportunities with certain probabilities assigned to them. EMV analysis is done along each branch, which helps you to make a decision about which option to choose.

Figure 11-3 presents a very simple decision-tree diagram that depicts two options: updating an existing product or building a new product from scratch. The initial cost for the update option is $50,000, whereas the initial cost for the build-from-scratch option is $70,000. However, the probability for failure is 40 percent for the update option, compared to 10 percent for the build-from-scratch option, and the impact from failure in both cases is a loss of $200,000. As Study Checkpoint 11.2 shows, even though the initial cost for the update option is less than the initial cost for the build-from-scratch option, the decision will be made in favor of the build-from-scratch option because when you combine the initial cost with the EMV resulting from the probability of failure, the build-from-scratch option turns out to be a better deal.

STUDY CHECKPOINT 11.2

Problem: Perform an EMV analysis of the decision tree presented in Figure 11-3 to make a decision on which option to take.

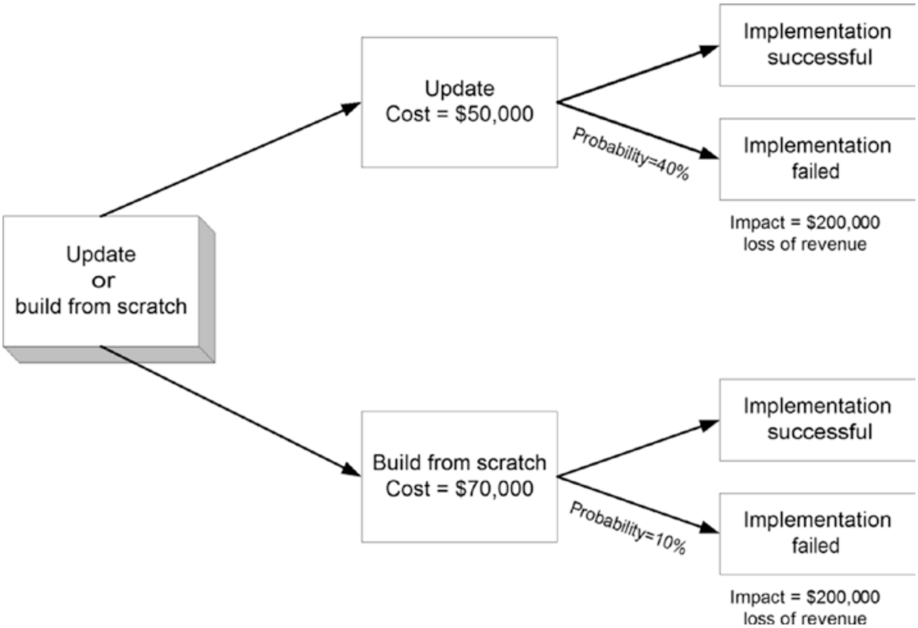

Figure 11-3. Example of a decision-tree diagram

Influence Diagram. An influence diagram is a graphical representation of uncertain situations that shows relationships among various variables and outcomes, such as causal influences and time-ordering of events. By examining these diagrams, the risk management team can recognize the potential problem areas and thereby identify risks in various options and make the right decisions under uncertainty.

Interviews and Expert Judgment. In quantitative risk analysis, interviews can be used as a data-gathering tool to get information from experts, and expert judgment can be used too; e.g.; selecting appropriate risk-modeling techniques, validating the collected risk data and the analysis used for the project at hand, and so on.

The risk register is updated with the results of the quantitative risk analysis.

Output of the Quantitative Risk Analysis: Updated Risk Report

The risk report that is used as an input item to the quantitative risk analysis is updated with the results of this analysis. The updates include the following:

- **Project Success: Probability of Achieving the Project Objectives.** Chances of project success are

evaluated by factoring in the project risks and estimating the probability of meeting project objectives, such as cost and schedule set forth by the current project plan. For example, the likelihood of completing the project within the current budget plan of $2 million is 70 percent.

- **Overall Project Risk Effect: Probabilistic Analysis of the Project.** This includes the key outputs from quantitative risk analysis, with some details, such as estimates of the project schedule and cost, with a confidence level attached to each estimate. Confidence level can be expressed in percentage form, such as 95 percent, and it represents how certain you are about the estimate. You can compare these estimates to the stakeholders' risk tolerances to see whether the project is within the acceptable limits. The detail can also include S-curve, tornado diagrams, and so forth.
- **Prioritized List of Risks.** The risks are prioritized according to the threats they pose or the opportunities they offer. The risks with greater threats (or opportunities) are higher on the list. The priorities are determined based on the total effect of each risk on the overall project objectives. The purpose of prioritizing risks is to help with planning the response efforts to eliminate (or minimize) the impact of the threats and capitalize on the opportunities.
- **Trends in the Results.** By repeating the analysis several times and examining the results, you might recognize a trend for specific risks. That trend might suggest further analysis or a specific risk response.
- **Risk-Response Recommendations**. The risk report can recommend a specific response to key risks based on their overall effect on the project.

The emphasis in quantitative analysis is on two tasks: assess the probability of meeting each project objective and prioritize the risks based on their total effect on the overall project objectives. Subsequently, the resulting prioritized list of risks can be used to prepare the risk response plan.

Planning the Risk Response Plan

The Plan Risk Response process develops the risk response plan, which includes options, actions, and strategies for responding to risks at both levels: individual project risks and overall project risk.

Accordingly, the central task in risk-response planning is to develop actions and options to meet the following three goals:

- Minimize threats to meeting project objectives.
- Maximize opportunities.
- Reduce the overall project risk effect.

Tip Remember the five-prong golden rule for risk-response planning, AARCO: A risk response must be *appropriate*, matching to the significance of the risk, *agreed* upon, *realistic* within the context of the project, *cost* effective, and *owned* by appropriate stakeholder.

The Table 11-8 presents the Plan Risk Response process in terms of input, tools and techniques, and output.

Core of Risk-Response Planning

Performing the Plan Risk Response process includes the following:

Table 11-8. The Plan Risk Response Process: Input, Tools and Techniques, and Output

Input	Tools and Techniques	Output
1. Project Management Plan: • Risk management plan • Recourse management plan • Cost baseline 2. Project documents: • Risk register • Risk report • Resource calendars • Project schedule • Project team assignments • Stakeholder register • Lessons learned register 3. Enterprise environmental factors 4. Organizational project assets	1. Data Gathering: • Interviews 2 Data Analysis: • Cost-benefit analysis • Alternatives analysis 3. Multicriteria decision-making analysis. 4. Strategies for negative risks: threats 5. Strategies for positive risks: opportunities 6. Strategies for overall project risk 7. Strategies for contingent response 8. Interpersonal and team skills: Facilitation 9. Expert judgment	1. Change requests 2. Management Plan Updates: • Schedule management plan • Cost management plan • Quality management plan • Resource management plan • Procurement management plan • Scope baseline • Schedule baseline • Cost baseline 3. Project document updates: • Risk register • Risk report • Cost forecasts • Project schedule • Project team assignments • Assumptions log • Lessons learned register

1. Determine the responses to individual project risks and overall project risk.
2. Determine the strategy to implement the responses.
3. Determine the response implementation–related activities and manage to insert them in appropriate project and plan documents.

In light of this, performing the Plan Risk Response process may be explained in the following steps in terms of the items from Table 11-8:

1. **Get Information about Risks and Response Strategy.** From the *risk report*, you can obtain a prioritized list of individual project risks, overall project risk, the specific response recommendations for key risks, and overall response strategy. More detailed information about any identified risks can be obtained from the *risk register*, such as priority, owner, cause, and data that may help to determine response.
2. **Get Information about Risk Owners and Roles.** The owner of each is assigned in the *risk register*. The *risk management plan* contains the information on risk management roles and the responsibilities assigned to each role, as well as the risk threshold. The owner and persons assigned to roles will play important roles in finding and allocating resources for implementing risk responses.
3. **Use Information about Risks to Determine Risk-Response Strategies.** Use these strategies to develop risk-response activities.
4. **Get Information about Resources to Implement Risk Responses.** From the project team assignments and resource calendars, you can get information on resources and their availability. Information on contingency funds allocated to risk responses can be found in the *cost baseline*.
5. **Integrate the Risk-Response Activities with Project.** From the *resource management plan*, get information on how the resources allocated to risk-response activities will be coordinated with other project resources. You will need the *project schedule* to schedule risk-response activities with other scheduled project activities.

For step 3, to consider different risk-response strategies and select appropriate ones for our project, we will need to use some tools and techniques.

Tools and Techniques for Risk-Response Planning

The main goal of this process is to determine the appropriate risk-response strategies and schedule the related activities. When developing risk responses, you can *interview* the appropriate stakeholders to collect needed information or data, and *interpersonal and team skills* like *facilitation* will be useful, such as to help the risk owner understand the risk and appropriate response strategy. You can also use expert judgment on the topic of different risk strategies.

To understand risk strategies, let's start from risk, which as you have already learned, can come in two categories: negative risks, which pose threats to meeting the project objectives, and positive risks, which offer opportunities. The goal here is to minimize the threats and maximize the opportunities. In project management, there are three kinds of possible responses to risks—take an action, take no action, or take a conditional action. When you want to take an action, different response strategies for negative and positive risks need to be planned. Also, we want to strategize the responses to overall project risk. Accordingly, there are three kinds of strategies available to handle three kinds of scenarios:

- Strategies to respond to negative risks (threats) when action is required
- Strategies to respond to positive risks (opportunities) when action is required
- Strategies that can be used to respond to overall project risks

Response Strategies for Threats

There are two strategies in which no proactive action is taken:

Escalate. The risks that are out of the scope of the project or project team authority are escalated to a higher level; e.g.; program, portfolio, or some other part of the organization. It is done with the consent of the project sponsor or another authorized person.

Accept. This strategy is usually applied to low-priority risks or risks for which there is no viable response. Here, the risk is accepted without taking any proactive action. In passive mode, nothing except periodic review is done until the risk priority gets higher. In active mode, some contingency resources are reserved to handle the situation if the risk occurs; this is called a contingent response.

For risks that need action by the project team, there are only three commonsense ways to take action against a potential problem: get out of harm's way, pass it to someone else, or confront it to minimize the damage. In project management, these three strategies are called avoid, transfer, and mitigate—the ATM approach.

Avoid. This is used for high-priority threats with high impact and high probability of occurring. The goal is to eliminate the risk or impact on the project; e.g.; you avoid the risk by changing your project management plan in such a way that the risk is eliminated. Depending upon the situation, this can be accomplished in various ways, including the following:

- Obtaining information and clarifying requirements for risks based on misunderstanding or miscommunication. This answers two questions: Do we really have this risk and, if yes, how can we avoid it?
- Removing the cause of the risk
- Acquiring expertise for risks that exist due to a lack of expertise
- Isolating the project objectives from the risk whenever possible
- Relaxing the objective that is under threat, such as extending the project schedule or putting resources to use

Transfer. Risk transfer means you shift the responsibility for responding to the risk (the ownership of the risk) and the negative impact of the risk to another party. Note that transferring the risk transfers the responsibility for risk management and does not necessarily eliminate the risk. Risk transfer almost always involves making payment of a risk premium to the party to which the risk has been transferred. Some examples include buying an insurance policy, contracting out the tasks involving risk, and risk transfers included in a agreement.

Mitigate. Mitigation in general means taking action to reduce or prevent the impact of a disaster that is expected to occur. Risk mitigation means reducing the probability of risk occurrence, reducing the impact of the risk if it does occur, or both. A good mitigation strategy is to take action early on to first reduce the probability of the risk happening, and then to plan for reducing its impact if it does occur rather than letting it occur and then trying to reduce the impact or repair the damage. The following are some examples of mitigation:

- Adopting less complex processes
- Conducting more tests on the product or service of the project
- Choosing a more stable supplier for the project supplies
- Designing redundancy into the system so that if one part fails, the redundant part takes over and the system keeps working

Each of these three strategies has a counter-strategy to deal with the opportunities.

Response Strategies for Opportunities

There are two strategies, *escalate* and *accept*, in which no proactive action is taken, and they are applied the same as in the case of threats.

For risks that need action by the project team, just like in the case of threats, you have three strategies to deal with opportunities. Not surprisingly, each response strategy to deal with an opportunity is a counterpart of a response strategy to deal with a threat—a one-to-one correspondence:

- *Share* corresponds to *transfer*
- *Exploit* corresponds to *avoid*
- *Enhance* corresponds to *mitigate*

You use the SEE (share, exploit, enhance) approach to deal with opportunities presented by the positive risks.

Share. Sharing a positive risk that presents an opportunity means transferring the ownership of the risk to another party that is better equipped to capitalize on the opportunity. Some examples of sharing are:

- Forming risk-sharing partnerships
- Starting a joint venture with the purpose of capitalizing on an opportunity
- Forming teams or special-purpose companies to exploit opportunities presented by positive risks

Exploit. This is used for high-priority opportunities with high impact and high probability of occurring. Exploiting an opportunity means ensuring that the opportunity is realized—that is, the positive risk that presents the opportunity does occur. This is accomplished by eliminating or minimizing the uncertainty associated with the risk occurrence. An example of exploiting is assigning more talented resources to the project to reduce the completion time and therefore to be the first to market. Another example could be to provide better quality than planned to beat a competitor, and using new technology. Whereas exploiting refers to ensuring that the positive risk occurs, enhancing refers to increasing the impact of the risk once it occurs.

Enhance. This strategy means increasing the size of the opportunity by increasing its probability, impact, or both. You can increase the probability by maximizing the key drivers of the positive risks or by strengthening the causes of the risks. Similarly, you can increase the impact by focusing on the factors that drive in risk impact.

You have just learned the different strategies that you need to plan for negative and positive risks if you intend to take action. If, on the other hand, you intend to take no action or a conditional action, then the response-planning strategies for both negative and positive risks are the same.

Response Strategies for Overall Project Risk

Overall project risk, like individual risk, can be either a threat or an opportunity. So, the same strategies as were used for individual risks can be applied to overall project risk in a similar manner. These strategies are share/transfer, exploit/avoid, enhance/mitigate, and accept.

Contingency

Generally speaking, *contingency* means a future event or condition that is possible but cannot be predicted with certainty. So, your action will be contingent upon the condition; that is, it will be executed only if the condition happens. In risk management, a contingent response is a response that is executed only if certain predefined conditions (or events) happen. These events trigger the contingency response. Some examples of such triggers are missing a milestone or escalating the priority of a feature by the customer. The events that can trigger a contingency response must be clearly defined and tracked.

Caution! While designing a response to a risk, also design a backup plan to fall back on in case the response does not work. Also, think through and plan for responding to the risks that the response to the original (primary) risk may cause. These risks are called secondary risks.

To select which of the strategies to apply for your project, you use data-analysis and decision-making techniques.

Data Analysis and Decision Making

Already discussed in this book more than once, *alternatives analysis*, *cost-benefit analysis*, and *multicriteria decision-making analysis* can be used to select the appropriate risk-response strategy in a given situation. In this process, alternatives analysis is applied by comparing the features and requirements of risk responses from different strategies, and in this way deciding which is best. In *cost-benefit analysis*, the cost effectiveness of a response is computed as:

cost effectiveness = (change in risk impact level) / (response implementation cost).

The higher the cost effectiveness value, the better the risk-response strategy.

In multicriteria decision-making analysis, the response strategies are selected by ranking them on several criteria; e.g.; resource availability, response effectiveness, creation of secondary risks by the response, and time constraints.

STUDY CHECKPOINT 11.3

You are the project manager of a movie project. The first column lists some actions you are taking to deal with risks. Match each item in the first column to one item in the second column of this table.

Action	Risk-Response Type
A. One of the scenes is to be shot in a country that has enormous bureaucracy and red tape. They possibly can create roadblocks and make it difficult for you. There is nothing much you can do about it.	1. Avoid
B. The jungle where you are going to shoot a few scenes is a wetland and very hot and humid, and the probability of damage happening to the equipment is very high. So, you have decided to buy insurance to protect you against this possible damage.	2. Accept
C. You have learned that during certain parts of the year, the locals hunt in the jungle in large numbers. So, you have decided not to do the shoot during that part of the year.	3. Exploit
D. Although the movie does not depend on it, it will add a lot of marketing value to the movie if your cameras could capture an endangered species of bird that lives in the jungle. You are choosing the time of year for shooting and taking some other actions to increase the probability that the birds will show up.	4. Share
E. The movie has something to do with Thanksgiving Day. You have allotted some extra resources to ensure that the movie is completed in a timely manner for a release on Thanksgiving Day.	5. Mitigate
F. You have learned that there could be mosquitoes in the area that you are going to shoot. So, you have planned to take plenty of mosquito repellant and other products to prevent mosquito bites.	6. Enhance
G. You know of another movie team that's going to shoot some scenes in the same jungle at a different time of the year. You have signed a contract with them to share or trade shots of the endangered bird species.	7. Transfer

You use these strategies to generate the output of the risk-response planning process.

Output of Risk-Response Planning

The main output of this process is appropriate risk response and strategies and the related schedule activities with assigned resources. The Plan Risk Response process does not create any such document as a risk response management plan. Instead, its output is inserted into already existing project plans and project documents as discussed in the following.

Risk Register and Risk Report Updates. The appropriate risk responses and strategies planned and agreed upon by the risk management team are included in the risk register. The responses to high- and moderate-priority risks are entered in detail, while the low-priority risks can be put on a watch list for monitoring. Other items added to the risk register as a result of this process may include the following:

- Planned and agreed-upon risk-response strategies and specific actions to implement each strategy
- Symptoms and warning signs of risk occurrences, contingency plans, and triggers for contingency risks
- Budget and schedule activities to implement the planned responses, including the contingency reserve, which is the amount of funds, time, or both needed
- Fallback plans in case the planned responses prove to be inadequate
- A list of risks to remain, which include the following:
    - Passive, accepted risks
    - Residual risks that will remain after planned responses have been performed
- A list of secondary risks that will arise as a result of implementing the responses. You must plan for these risks like any other risk.

Similarly, the *risk report* can be updated with planned responses to the overall project risk and the resulting impact changes that are expected from the implementation of these responses.

Other Document Updates. The documents that may change in this process are listed in the output column of Table 11-8. The change or update is triggered by the action of inserting the output of this process into project plans and project documents. For example, scheduling the risk response–related activities updates the *project schedule* and *project team assignments*. These changes may require or lead to changes in or updates to the *scope baseline, schedule baseline, cost baseline*, and other items listed in the output column of Table 11-8.

Change Requests. For proposed changes to any component of the project plan, such as *scope baseline, schedule baseline,* and *schedule management plan, change requests* must be generated and processed through the Perform Integrated Change Control process.

Note A residual risk is the remains of a risk for which a response has been performed, whereas a secondary risk is a risk that is expected to arise as a result of implementing a risk response; therefore, a response for a secondary risk must be planned.

In a nutshell, risk-response planning examines and selects the risk-response strategies, uses these strategies to plan responses to individual project risks and overall project risk, and assigns resources to these response activities and schedules them.

Once risk responses have been planned, you need to implement them.

Implementing Risk Responses

The Implement Risk Responses process makes sure that all the planned risk responses are executed as planned. Remember, the goal here is to minimize the impact of threats and maximize the impact of opportunities on the project. Table 11-9 presents the Implement Risk Responses process in terms of input, tools and techniques, and output.

Table 11-9. The Implement Risk Responses Process: Input, Tools and Techniques, and Output

Input	Tools and Techniques	Output
1. Project Management Plan: • Risk management plan 2. Project documents: • Risk register • Risk report • Lessons learned register 3. Enterprise environmental factors	1. Project management information system 2. Interpersonal and team skills: Influencing 3. Expert judgment	1. Change requests 2. Project document updates: • Risk register • Risk report • Project team assignments • Issues log • Lessons learned register

Recall that planned risk-response activities have already been scheduled with resources assigned to them through the Plan Risk Responses process. In this process, you make sure they are executed. That said, the Implement Risk Responses process may be explained in the following steps in terms of the items from Table 11-9:

1. **Get "How-to" and Other Information about Risk.** The "how-to" information from this process can be found in the *risk management plan*, which also contains information on

    - risk management roles and responsibilities assigned to each role; these persons will play important role in implementing risk responses; and
    - risk thresholds acceptable to relevant stakeholders; i.e., the acceptable remaining risk impact level after risk implementation.

2. **Get Information about Risks and Planned Risk Responses.** From the *risk report*, you can obtain information on the overall project risk and planned responses to it. The detailed information on the individual risks, their owners, and planned responses is in the *risk register*.

3. **Ensure the Planned Responses Are Implemented.** You can use the *influence* skill to help the relevant stakeholders, e.g.; risk owner, realize that it is time to take action. To validate or modify risk responses before and after their implementation, you can use *expert judgment* from an appropriate source.

4. **Integrate Activities.** You can use tools available in the *project management information system*—e.g.; software to manage resource, cost, and schedule—to seamlessly integrate the risk-response activities and other project activities, and in this way keep both kinds of activities synchronized.
5. **Modify Documents.** The documents that may change in this process are listed in the output column of Table 11-9. For example, the *project team assignments* will be updated with allotted resources like funding and persons to execute response. As a result of risk implementation, the *risk register* and *risk report* will be updated with a modified set of "to implement" responses to individual risks and overall project risk, respectively.
6. **Generate Needed Change Requests.** During or as a result of executing this process, some changes may be needed, such as more funds or a schedule change. As always, for proposed changes to any component of the project plan, such as schedule baseline or cost baseline, change requests must be generated and processed through the Perform Integrated Change Control process.

While performing all these processes in risk management, the risks need to be monitored.

Monitoring Risks

Risks are monitored by using the Monitor Risks process, which includes the following:

- Tracking the status of identified risks
- Monitoring residual risks (risks that remain after risk responses have been implemented)
- Identifying new risks and making sure that they are analyzed and responded to if needed
- Evaluating the effectiveness of risk processes

However, the risk situation can change with time. Therefore, monitoring and controlling risks also includes monitoring risk dynamics, which involves the following:

- Ensuring that the project execution is conforming to the risk management policies and procedures.

- Determining whether the project assumptions are still valid. If an assumption becomes invalid, it may eliminate a risk or give rise to a new risk.
- Determining whether the current analysis has changed the risk assessment. The change in the risk assessment may require changes in other aspects of the project, such as cost, schedule, and contingency reserves.

The Table 11-10 presents the Monitor Risks process in terms of input, tools and techniques, and output.

Table 11-10. The Monitor Risks Process: Input, Tools and Techniques, and Output

Input	Tools and Techniques	Output
1. Project Management Plan: • Risk management plan 2. Project documents: • Risk register • Risk report • Issues log • Lessons learned register 3. Work performance data 4. Work performance report	1. Data analysis: • Technical performance analysis • Reserve analysis 2. Audit 3. Meetings	1. Work performance information 2. Change requests 3. Project management plan update: any component 4. Project document updates: • Risk register • Risk report • Assumptions log • Issues log • Lessons learned register 5. Organizational project assets updates

That said, the Monitor Risks process may be explained in the following steps or tasks in terms of the items from Table 11-10:

1. **Get "How-to" and Other Information about Risk.** The information about how, how often, and when risks should be reviewed can be found in the *risk management plan* that also contains information on risk management roles and the responsibilities assigned to each role to monitor risks.

2. **Get Information about Risks and Planned Risk Responses.** From the *risk report*, you can obtain up-to-date information on the overall project risk and planned responses to it. All information on the individual risks needed for this process can be obtained from the *risk register*.

3. **Get Project Risk Results.** You can get risk-related results from the project execution from *work performance data*, an output of the Direct and Manage Project Work process, and from the *work performance report*, an output of the Monitor and Control Project Work process. The *work performance data* basically provides the project status, including the risk status, such as risks to which the responses have been implemented, those currently active, those already closed out, and those newly occurred. The *work performance report* contains information about work performance measurements. The data and information from both of these documents are analyzed to assess the effectiveness of risk management, as shown next.

4. **Generate Work Performance Information, an Output Item.** As already mentioned, the *work performance report* contains the information about work performance measurements, which can be analyzed to generate *work performance information*, which includes how much the risk results vary from the plan, and earned values and forecast in terms of risks. In a nutshell, the *work performance information* tells how effective the risk response and implementation processes are. You can also use relevant data from the work performance data in the preparation of the *work performance information.*

5. **Technical Performance Measurement.** Technical performance analysis compares actual versus planned quantities related to the technical progress of the project. The deviation determines the degree of the potential impact of risks. For example, for a software product project, the technical performance measurement quantities could include running time of a module to complete a job, number of bugs, and how often the program crashes. In general, the parameters and quantities chosen to measure technical performance could be any parameters that represent something important related to the project objectives and requirements; software performance, human resource performance, and system test performance are some examples.

6. **Reserve Analysis.** Recall that the contingency reserve is the amount of funds or time (in the schedule) in addition to the planned budget that is reserved to keep the impact of risks to an acceptable level when the project is executing. The risks occurring during project execution can have positive or negative effects on the contingency reserve. You perform reserve analysis at a given time to compare the remaining reserve amount to the remaining risk to determine whether the remaining reserve amount is adequate to handle the risk.
7. **Audit.** You will be responsible for conducting risk audits with the frequency suggested in the risk management plan. These audits are usually done to assess the effectiveness of risk management processes. They may be conducted as a part of project review meetings or risk review meetings, or just separate audit meetings. As is true for any audit and meeting, the objective should be clearly defined before it starts.
8. **Risk Review Meetings.** You can put risk reviews as an agenda item at project status meetings or hold separate risk review meetings. These regular reviews can include activities such as assessment of current risk, closing outdated risks, identifying new risks or secondary risks that occurred as a result of applying the responses, recoding lessons learned, and discussing other risk-related issues. Having these risk reviews on a regular basis helps make risk management smoother and more effective.
9. **Modify Documents.** The documents that may change in this process are listed in the output column of Table 11-10. For example, as a result of risk monitoring, the risk register and risk report will be updated with new information and the status of individual risks and overall project risk, respectively. Also, the risk report can include the results of risk audits on the current effectiveness of the risk management processes.

   As a result of the risk monitoring and controlling processes, some *organizational process assets* might need to be updated, such as savings templates for the project management plan, risk register, risk report, risk breakdown structure (RBS), and the lessons learned knowledge database.

10. **Generate Needed Change Requests.** During or as result of monitoring risks, some changes may need to be made; e.g.; preventive or corrective action, more funds, or schedule change. As always, for proposed changes to any component of the project plan, such as schedule baseline or cost baseline, change requests must be generated and processed through the Perform Integrated Change Control process.

STUDY CHECKPOINT 11.4

Q1. Why do you end up updating the *assumptions log* and *lessons learned register* during the Monitor Risks process?

Q2. The *work performance information,* an output item of the Control Risks process, is an input to which process?

Q3. Which other processes generate *work performance information*?

The qualitative risk analysis prioritizes these risks based on the probability and impact matrix for each objective, whereas the emphasis in quantitative risk analysis is on assessing the probability of meeting each project objective and prioritizing the risks based on the total effect of each risk on the overall project objectives.

The three most important takeaways from this chapter are as follows:

1. The risk identification process initiates the risk register and risk report, which are added to or modified by other risk management processes.
2. The goal for risk-response planning is to minimize the threats (the negative effects of risks) and maximize the opportunities (the positive effects of risks).
3. The risk monitoring process is used to not only monitor the identified risks, secondary risks, and residual risks, but also to identify new risks and put them onto the path of analysis to response management.

Summary

Risk refers to an uncertain event or condition that, if it occurs, has a positive or negative effect on meeting the project objectives, hence posing threats or offering opportunities, respectively. Risk management includes planning risk management, identifying and analyzing the risks, planning and preparing the risk responses, implementing the risk response if the risk occurs, and monitoring the risks. The only output of risk management planning is the risk management plan, which includes elements such as a list of tools and approaches to be used for risk management, identification and assignment of resources for risk management, definition of risk categories, risk probabilities and impacts, and the format of risk reporting and tracking. This information is used in the remaining processes of risk management—Identify Risks, Perform Qualitative Risk Analysis, Perform Quantitative Risk Analysis, Plan Risk Responses, Implement Risk Reponses, and Monitor Risks.

The risk identification process initiates two documents as output: the *risk register*, which contains information about identified individual project risks, and the *risk report*, which contains information about overall project risk. Both of these items are added to or modified by other risk management processes. The main output of qualitative risk analysis is the prioritization of risks based on a probability and impact matrix for each objective. Each objective might have its own prioritized list of risks. However, the emphasis in quantitative analysis is on two things—assessing the probability of meeting each project objective and prioritizing the risks based on the total impact of each risk on the overall project objectives. Subsequently, the resulting prioritized list of risks can be used to prepare the risk response plan.

Risk-response planning examines and selects the risk-response strategies, uses these strategies to plan responses to individual project risks and overall project risk, and assigns resources to these response activities and schedules them. This risk response plan is executed to minimize the impact of threats and maximize the impact of opportunities on the project. While performing all these processes in risk management, you monitor risks by activities such as tracking the status of identified risks, evaluating the effectiveness of risk processes, and identifying new risks.

Road Ahead: While performing risk management, do not lose sight of the risks attached to the items that are to be procured. Procurement management is discussed in the next chapter.

Exam's Eye View

Comprehend

- Risk categorization is a part of the risk management plan and helps in the risk identification process.
- Defining the risk probability and risk impact are parts of the risk management plan, and they are assessed in the qualitative risk analysis to prioritize risk.
- Risk identification is performed before any risk analysis, and the qualitative risk analysis, if performed, is performed before quantitative risk analysis because it takes less effort and time and its results can be used for quantitative analysis.
- The emphasis in quantitative analysis is on two tasks: assess the probability of meeting each project objective and prioritize the risks based on their total effect on overall project objectives.
- An important update added to the risk register by the qualitative and quantitative risk analyses is the prioritized list of risks.
- Implementation of risk responses is managed by the Implement Risk Responses process and not by the Monitor Risks process.
- The risk response plan is executed to minimize the impact of threats and maximize the impact of opportunities on the project.

Look Out

- Risk stems from elements of uncertainty and can have a negative or positive effect on meeting the project objectives. Positive effect is called opportunity.
- The risk register and risk report are initially prepared during the risk identification process, and some results of the other risk management processes are added to them.
- Depending upon the experience of the team and the nature of the risk, a risk can be moved directly after identification to the quantitative risk analysis or even to risk-response planning.
- For simple projects, quantitative risk analysis may not be needed.
- There is no document called a risk response management plan. The risk response–related activities are inserted into appropriate project and plan documents.
- A residual risk is the remains of a risk on which a response has been performed, whereas a secondary risk is a risk that arises as a result of implementing a risk response.

Memorize

- A prompt list is a predetermined list of risk categories that can be used to generate ideas to identify individual project risks.
- The risk register contains information about individual project risks, and the risk report contains information about the sources of overall project risks and a summary of individual project risks.
- Work performance data generated by the Direct and Manage Project Work process is used as an input to the Monitor Risks process to generate work performance information.

Review Questions

1. Which of the following is a false statement about project risks?
   - A. A risk arises out of uncertainty.
   - B. A risk can only have a negative effect on a project.
   - C. Identified risks are usually listed in a document called the risk register.
   - D. Risks can be categorized by developing a risk breakdown structure (RBS).
2. The risk register is not an input to which of the following processes?
   - A. Identify Risks
   - B. Perform Qualitative Risk Analysis
   - C. Perform Quantitative Risk Analysis
   - D. Implement Risk Responses
3. Which of the following is not an information-gathering technique listed in PMBOK Edition 6 for use in the risk identification process?
   - A. Brainstorming
   - B. Delphi technique
   - C. SWOT analysis
   - D. Root-cause analysis
4. Which of the following statements about risk analysis is false?
   - A. Quantitative risk analysis can only be performed on risks on which a qualitative risk analysis has already been performed.
   - B. Qualitative risk analysis is usually performed before quantitative risk analysis.
   - C. An updated risk report is the output of both qualitative risk analysis and quantitative risk analysis.
   - D. The risk register is an input to both qualitative risk analysis and quantitative risk analysis.

5. You are managing a project to set up data servers to support a website for an enterprise customer. The location of the servers has been chosen to be close to the customer due to their requirements. However, this location is prone to natural disasters, such as hurricanes and flooding. You have decided to install some extra servers in another city that will act as backup if a disaster happens. This is an example of which of the following?

   A. Risk avoidance

   B. Risk mitigation

   C. Risk acceptance

   D. Risk transfer

6. The risk management team of a software project has decided that due to the lack of adequate talent in your company, development of a specific part of the system is under high risk, so they have decided to outsource it. This is an example of which of the following?

   A. Risk avoidance

   B. Risk mitigation

   C. Risk acceptance

   D. Risk transfer

7. You are in the process of evaluating the probability and impact of a risk by assigning numbers, such as expected monetary value. This is an example of which of the following?

   A. Monte Carlo simulation

   B. Qualitative risk analysis

   C. Quantitative risk analysis

   D. Risk-response planning

8. Consider Figure 11-4. Assume that the risk has a 50 percent probability of occurrence. If the risk does occur, it could have a positive or a negative impact equivalent to $200,000 or $50,000, respectively, with the probabilities shown in the figure.

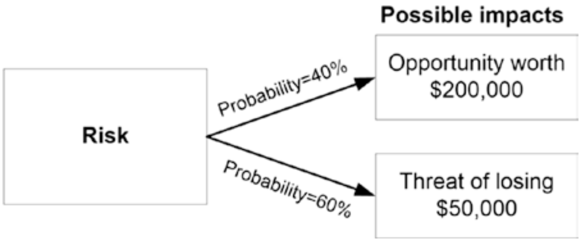

Figure 11-4. Example of positive and negative risk impact

What is the EMV for the positive impact?

A. $80,000

B. $200,000

C. $50,000

D. $40,000

9. Consider Figure 11-4. Assume that the risk has a 50 percent probability of occurrence. If the risk does occur, it could have a positive or a negative impact equivalent to $200,000 or $50,000, respectively, with the probabilities shown in the figure. What is the EMV for the risk?

A. $25,000

B. $55,000

C. $110,000

D. $50,000

10. Which of the following is a correct statement about secondary risks?

A. These are the residual risks.

B. These are the risks that have medium or low priority.

C. These are the risks that will be avoided.

D. These are the risks that can result from responses to the identified risks.

11. Which of the following is not a valid risk response?

A. Risk acceptance

B. Risk sharing

C. Risk mitigation

D. Risk rejection

12. Which of the following is a valid statement about SWOT?
    A. It is an analysis technique to identify risks.
    B. It refers to the analysis of scope, work, options, and timing.
    C. It is a technique used to plan a risk response.
    D. It is a technique used to perform quantitative risk analysis.
13. Which of the following is not an output of qualitative risk analysis?
    A. A prioritized list of risks for a given project objective based on the probability and impact matrix of the objective
    B. A watch list of low-priority risks
    C. A list of risks prioritized based on the total effect of each risk on the overall project objectives
    D. A list of trends in the analysis results
14. Which of the following is not an output of quantitative risk analysis?
    A. Probability of meeting the project objectives, such as cost and schedule
    B. A list of risks prioritized based on the total combined effect of each risk on the overall project objectives
    C. A list of trends in the analysis results
    D. Decision about a risk-related contractual agreement
15. A project manager is recommending corrective actions related to risk. In which of the following processes is the project manager involved?
    A. Perform Integrated Change Control
    B. Plan Risk Responses
    C. Identify Risks
    D. Monitor Risks

16. A project manager is getting the risk-related recommended corrective actions approved. In which of the following processes is the project manager involved?

    A. Perform Integrated Change Control

    B. Plan Risk Responses

    C. Identify Risks

    D. Monitor and Control Risks

17. In project risk management, which of the following statements is not true?

    A. The risk report contains information about the overall project risk.

    B. Exploiting an opportunity ensures that the positive risk does occur.

    C. An output of the Implement Risk Responses process is a document called risk response plan.

    D. The lowest level of RBS can often be used as a checklist, which could be the list of risk categories.

18. Which of the following is not an input to the Monitor Risks process?

    A. Work performance reports

    B. Work performance information

    C. Work performance data

    D. Risk management plan

CHAPTER

12

Project Procurement Management

The objectives covered in this chapter make up 4 percent of the exam, equivalent to about 4 questions. Study the whole chapter in detail.

It's enough to just remember the name of the input, tools and techniques, and outputs. You should know what is in a given input item that the given process uses and how it helps generate the output, as well as what a given tool or technique does in a given process.

You should understand very well how to apply procurement management concepts, tools, and methods, such as make-or-buy analysis, source-selection analysis, contract types, bid documents and procurement documentation, audits and inspections, and earned value analysis.

P. Sanghera, *CAPM® in Depth*, https://doi.org/10.1007/978-1-4842-3664-2_12

CAPM Exam Objectives

Project Procurement Management:

1. Understand the three processes in the project procurement management knowledge area.
2. Identify the inputs, tools and techniques, and outputs defined in the three project procurement processes.
3. Identify key concepts and tailoring considerations for project procurement management, including trends and emerging practices.
4. Identify various types of contracts, agreements, source-selection methods, and contract types.

Some of the expected outcome items of the project will be developed by the project team, while others will be purchased or acquired, a process called *procurement*, which may also include items that are needed to complete the project and are not necessarily the end product of the project. Project management includes processes for acquiring products, services, or results from outside the project. Obviously, you need to plan for these procurements, and then you need to follow up on your plan and conduct these procurements. As you can imagine, procurement management, like any other process area, will need to be monitored or controlled.

So, the core question in this chapter is: how do you manage procurements? This issue breaks down into three avenues that we will explore: planning procurements, conducting procurements, and controlling them.

Procuring the Project Resources: Big Picture

Procurement refers to obtaining—purchasing or renting—products, services, or results, collectively called procurement items, from outside the project team to complete the project. Accordingly, procurement management is the performing of a set of processes used to plan and obtain (procure) those things from outside the project team to complete the project.

There are two main roles involved in procurement management:

- **Buyer.** The party purchasing—i.e., procuring—the items
- **Seller.** The party delivering the procurement items to the buyer

As illustrated in Figure 12-1, procurement management includes the following components:

1. **Plan Procurements.** This is the process of making purchasing decisions on what to procure, identifying potential sellers, determining the procurement strategy, and making the overall procurement management plan.
2. **Conduct Procurements.** This is the process of soliciting seller responses, selecting sellers, and awarding contracts.
3. **Control Procurements.** This is the process of monitoring and controlling the contract execution, making approved changes and corrections, managing relationships among the parties involved in the procurement, and obtaining the procurement items.

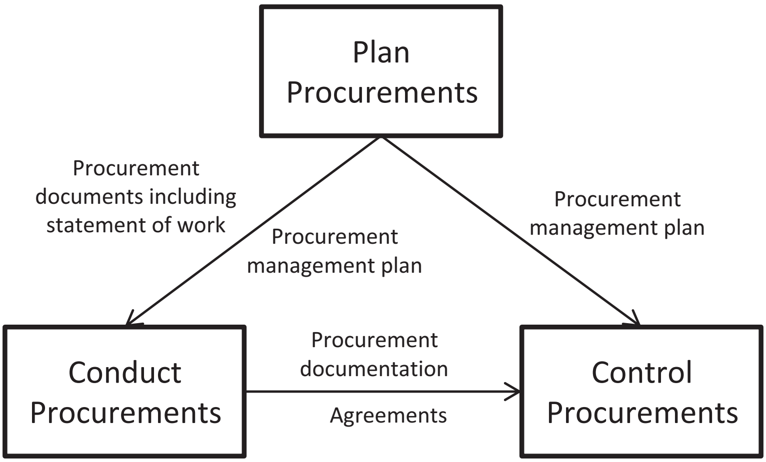

Figure 12-1. Big picture of procurement management

Table 12-1 lists the procurement management processes along with their process groups and major outputs.

Table 12-1. Processes of Procurement Management Mapped to the Process Groups

Procurement Management Process	Process Group	Major Output
Plan Procurements	Planning	Procurement management plan, including procurement statement of work and make-or-buy decisions.
Conduct Procurements	Executing	Selected sellers, agreements, and change requests
Control Procurements	Monitoring and Controlling	Closed procurements, work performance information, change requests

Caution! Referring to Figure 12-1, procurement documentation refers to all the records of procurement; it keeps on growing. So, it wouldn't be identical for the Plan Procurements and Conduct Procurements processes.

Before you can conduct procurements, you've got some planning to do.

Planning for Procurement

Planning procurements includes making and documenting purchasing decisions on what to acquire from outside of the project, and when; identifying potential sellers; and developing a procurement approach. Although procurement planning should be done early in the project, like most of the planning, the need might also emerge at any stage due to approved changes or other circumstances. Table 12-2 presents the Plan Procurement Management process in terms of input, tools and techniques, and output.

Table 12-2. The Plan Procurement Management Process: Input, Tools and Techniques, and Output

Input	Tools and Techniques	Output
1. Project charter 2. Business documents: • Business case • Benefit management plan 3. Project Management Plan: • Scope management plan • Scope baseline • Resource management plan • Quality management plan 4. Project documents • Milestones list • Project team assignments • Requirement documentation • Requirement traceability matrix • Resource requirements • Stakeholder register • Risk register 5. Enterprise environmental factors 6. Organizational project assets	1. Data gathering: • Market research 2. Data analysis: • Make-or-buy analysis 3. Source-selection analysis 4. Expert judgment 5. Meetings	1. Procurement management plan 2. Procurement strategy 3. Make-or-buy decisions 4. Statement of work (SOW) 5. Bid documents 6. Source selection criteria 7. Independent cost estimates 8. Change requests 9. Project document update: • Milestones list • Requirement documentation • Requirement traceability matrix • Stakeholder register • Risk register • Lessons learned register 10. Organizational project assets

Core of Performing Plan Procurement Management

Performing the Plan Procurement Management process can be explained in the following steps in terms of the items from Table 12-2:

1. **Get High-level Project Information.** Because you are considering acquiring a piece or component of the project, you better have a good overall understanding of your project. Get information about project objectives, milestone summary, approved resources, and description from the *project charter*; and what the project benefits are and when they are expected to be yielded from the *benefit management plan*. For example, the *milestones list* determines delivery time from the sellers. Also, you will want to know about the project's *business case* so as to keep the procurement strategy aligned with it.

2. **Fetch Information about Procurement Scope.** From the *scope baseline*, draw the scope of the component to be procured, and from the *scope management plan* you will know how this scope will be managed. This will help you to develop a *statement of work (SOW)* and *terms of reference (TOR)*.

3. **Know What to Procure.** Steps 1 and 2 will expose what needs to be procured. The *resource management plan* and *resource requirements* may already have information about resources that need to be procured. From the *quality management plan*, you can get quality information such as standards and codes that the project needs to follow; this information may be used in bidding documents, determining supplies' prequalification, and determining selection criteria. Also, from information in the *project team assignments*, you can determine if some team members would be able to perform the procurement activities or if additional resources need to be acquired or procured.

4. **Get Requirements of Procurement.** From *requirement documentation*, you can fetch the requirements for the items to be procured, which you and other sellers will need to follow. These may include technical requirements and requirements with legal and contractual obligations, such as safety, security, permit, and intellectual property rights. You can use the *requirement traceability matrix* to link seller deliverable requirements to the product requirements.

5. **Get Information about Relevant Risks and Stakeholders.** From the *risk register*, get information about risks belonging to the items to be procured; these risks will need to be transferred to the procurement contract. Also, get information about contract and legal personnel, as well as regulatory agencies, from the *stakeholder register*.
6. **Consider Enterprise Environmental Factors.** When handling procurement, consider relevant EEFs, such as market conditions; availability of the product in the market; past performance of the potential suppliers; unique local conditions regarding regulation, labor, sellers, and so forth; contract management and payment systems; and financial accounting systems.
7. **Consider Organizational Process Assets.** When handling procurement, also consider relevant OPAs, such as procurement policies and procedures of the performing organization; approved list of sellers; and different contract types supported by the organization, which may include fixed price (FP), cost-reimbursable contracts, and time and material (T&M) contracts.
8. **Decide Whether to Make or Procure.** Information collected during steps 1 through 7 will also help in determining whether an item is to be made or a piece of work is to be performed by the project team or be procured.

In order to determine what type of contract you will use for the procurement, you need to be aware of what contract types are supported by the organization and what they are.

Determining Contract Types

A contract is a mutually binding agreement between a buyer and a seller that obligates the seller to provide the specified product, service, or result and obligates the buyer to make the payment for it. Contracts generally fall into the three categories discussed in this list.

Fixed-price Contracts. A fixed-price contract is a contract that contains a fixed price, used for a well-defined product, with the expectation that the scope will not change. Actually, this contract may contain another cost component in addition to the fixed price. This gives rise to various sub-types of fixed-price contracts:

- **Firm Fixed Price (FFP).** Also sometimes called a *lump-sum contract*, this is an agreement that specifies the fixed total price for the product, service, or result to be procured. The price is set in the beginning and is not subject to change unless the scope of the product or the service changes. This type is commonly used, and is preferred by buyers. An example of a firm fixed-price contract is a purchase order for the specified item to be delivered by a specified date for a specified price. This category of contract is generally used for products and services that are well defined and have good historical information. A firm fixed-price contract for a poorly defined product or a service with very little historical record is a source of high risk for both the seller and the buyer.
- **Fixed Price with Economic Price Adjustment (FPEPA).** This is a fixed-price contract that contains a special provision to adjust the price according to changes in external conditions, such as inflation or price changes for some specific commodities relevant to the product or service to be procured. The adjustments are well defined at the start. For example, this contract type is useful when the seller delivers over a long period during which external conditions such as inflation or currency rate may change.
- **Fixed-price Incentive Fee (FPIF).** This is a fixed-price contract that contains extra rewards for the seller tied to achieving the agreed-upon metrics, the quantitative measures of performance used to express progress or achievement against the planned goals. These metrics or performance targets are defined at the beginning (outset), and the total price—including the incentives—will be determined at the end of the work. The performance metrics may include cost and schedule in addition to other factors, such as technical performance. This contract type offers some flexibility in deviating from the target goals.

Cost-reimbursable Contracts. A contract in this category includes two kinds of costs:

1. **Actual Cost.** This is the payment (reimbursement) to the seller for the actual cost of the item or work.
2. **Fee.** This typically represents the seller's profit.

This contract type is used when the work scope is expected to change. As discussed in the following list, there are three types of cost-reimbursable contracts:

- **Cost Plus Fixed Fee (CPFF).** The payment to the seller includes the actual cost and a fixed fee. The fixed fee can be calculated as a percentage of the initially estimated project cost. In this case, the CPFF is sometimes also called the cost-plus percentage of cost (CPPC). The fee is fixed and does not vary unless the scope changes.
- **Cost Plus Incentive Fee (CPIF).** The payment to the seller includes the actual cost and a predetermined incentive bonus based on achieving certain objectives. If the actual cost is predetermined in the contract, and the final cost deviates from the estimate, the buyer and seller usually split the difference based on the pre-determined formula.
- **Cost Plus Award Fee (CPAF).** In structure, this sounds pretty much like CPIF. The payment to the seller includes all the legitimate costs and an award fee. However, the award fee may be based on meeting broadly defined performance objectives. If the performance is broadly defined, the determination of the award fee may depend on the subjective judgment by the buyer; it is not subject to appeal.

Note Both fixed-price contracts and cost-reimbursable contracts can optionally include incentives—for example, a bonus from the buyer to the seller if the seller meets certain target schedule dates or exceeds some other predetermined expectations.

Time and Material (T&M) Contracts. Also referred to as *time and means*, this type of contract is used in situations where both cost-re-imbursement and fixed-price features need to be applied. In other words, this is a hybrid that contains some aspects from both the fixed-price category and the cost-reimbursable category. The contracts in this category resemble the contracts in the cost-reimbursable category because the total cost and the exact quantity of the items is not fixed at the time of the agreement. The contracts resemble fixed-price contracts because the unit rates can be fixed in the contract. These types of contracts are useful when you do not know the quantity of the procured items. For example, you do not know how much time a contract programmer will take to develop a software program, so you determine the hourly rate in the contract, but not the total cost for writing the program. In this category of contracts, the risk is high for the buyer because the buyer agrees to pay for all the time the seller takes to produce the deliverables.

Table 12-3 shows lists of risk bearers for various types of contracts.

Table 12-3. Lists of Risk Bearers for Various Types of Contracts

Contract Type	Risk Bearer	Explanation
Fixed Price (FP)	Buyer and Seller	The cost overrun is borne by the seller, whereas the price's being fixed higher than the actual cost hurts the buyer.
Cost Plus Fixed Fee (CPFF)	Buyer	Cost overrun is paid by the buyer.
Cost Plus Award Fee (CPAF)	Seller	Award fee is usually the major part of the cost and is based on the subjective determination of the seller's performance by the buyer.
Cost Plus Incentive Fee (CPIF)	Buyer and Seller	Cost overrun is shared by the buyer and the seller.
Time and Material (T&M)	Buyer	The increased cost due to the increased quantity of resources, such as work hours by a contractor, is borne by the buyer.

STUDY CHECKPOINT 12.1

Rajinder, the project manager, is now working on procurement planning for a portion of the project. She is looking at all the following options for procuring different pieces. Match each consideration in the first column with the corresponding contract type in the second column of the following table.

Consideration	Contract type
A. Rajinder will pay $3,000 for the use of a facility and $5,000 per month for the employees working for the procured piece for the duration of work. However, there is a cap of $50,000 for the maximum cost.	1. Fixed Price (FP)
B. Rajinder will pay for the labor of the cost and a lump sum of $5,000	2. Time and Material (T&M)
C. Rajinder will pay $50,000 to maintain the website for the project for two years.	3. Cost Plus Fixed Fee (CPFF)
D. She will provide $10,000 for developing a software program and an extra $1,000 if less than 10 bugs are discovered in the program in the first year of its use.	4. Cost Plus Percentage of Cost (CPPC)
E. She will pay the labor cost each month plus 5 percent of this cost as coffee and snacks at work and for recognition and rewards for the labor.	5. Cost Plus Incentive Fee (CPIF)

Tools and Techniques for Planning Procurement Management

Various tools can be used in planning procurement management, such as market research, make-or-buy decision analysis, and source-selection analysis.

Market Research Analysis. Market research, in this process, is conducted via data-gathering techniques and is focused on the industry and seller qualifications regarding the items to be procured. For this analysis, the sources of information that can be used include relevant conferences, web reviews, and industry magazines. In your analysis, you may have to consider and balance between various factors, including the many options for technology and sellers, maturity of technology, and risks to meet the procurement objectives.

Make-or-Buy Decision Analysis. Obviously, procurement refers to buying something as compared to making it in-house in the project. The make-or-buy decision analysis can be used to determine if the item should be procured or made in-house by the project team. The factors considered in this analysis include the organization's current resource allocation, availability of resources with the right skills and abilities, need for special and rare expertise, and risks. An example of factors is listed in Table 12-4.

Table 12-4. Some Factors and Reasons to Make or Buy

Factor	Reasons to Make In-house	Reasons to Buy
Cost	Less cost	Less cost
Skills availability	Use in-house skills	In-house skills don't exist or are not available
Skills acquisition	Learn new skills that will be used even after this project	These skills are not important to the organization
Risks	Deal with the risk in-house	Transfer the risk
Work	Core project work	Not core project work
Human resource availability	Staff available	Vendor available

The make-or-buy decision analysis may also use techniques like cash flow, net present value, cost-benefit analysis, and return on investment. This analysis will generate a make-or-buy decision, an output item of this process.

Source-Selection Analysis. This analysis is performed by the buyer to develop *source-selection criteria,* also called *evaluation criteria*, during procurement planning to rate responses from the sellers. Depending on the procurement need, the evaluation criteria could be as simple as the price for

off-the-shelf standard items, or it could be a combination of factors for a more complex proposal. The common methods used in this analysis are explained in Table 12-5.

Table 12-5. Methods to Be Considered in the Source-Selection Analysis

Selection Method	Why	Summary
Least cost	Procurement is of routine nature with well-established standard.	Items with different prices will generate the same well-defined output.
Quality based	High-quality technical solution is main priority	Seller with highest ranked technical proposal is selected given that the related cost is accepted after possible negotiations. Also called: Highest technical proposal score
Quality and cost based	Cost matters in addition to quality	Strike the right balance between quality and cost; e.g.; for a high-risk project, quality will have higher priority than cost.
Qualifications only	Value of procurement is relatively low	Bidder with best relevant expertise, capabilities, skills, experience, and qualification is selected.
Sole source	The seller is a given	A particular seller is asked to submit technical and financial proposals, which are negotiated. Since no competition, seller must be justified.
Fixed budget	Cost constraints	Fixed budget must be disclosed to the sellers. Seller with highest ranked technical proposal within the budget is selected. Caution: To ensure that scope and quality are not compromised, SOW must be precise and must be checked against the proposal.

Caution! Selections are made based on the need and priorities of procurement. In a competitive bidding, all sellers should be provided with the same required information, such as the proposal evaluation methods to be used in the selection.

As said earlier, source-selection analysis is performed to develop source-selection criteria, in which the sellers' factors could also matter:

- **Business Aspects.** This can include the following factors:
    - **Business Size and Type.** Does the business size or type meet a condition set forth in the contract, such as being a small business or a disadvantaged small business?
    - **Financial Capacity and Stability.** Does the seller have the financial capacity to do the job, or is the seller in a position to obtain the necessary financial resources to do the job?
    - **Production Capacity and Interest.** Does the seller have the capacity and the interest to meet future potential requirements?
- **Technical Aspects.** This includes the technical approach and capability:
    - **Technical Approach.** Will the technical methodologies, techniques, solutions, or services proposed by the seller meet the procurement requirements, or will they provide more than the expected results?
    - **Technical Capability and Expertise.** Does the seller have or is the seller capable of acquiring the technical skills and knowledge required to produce the deliverables?

Other. Delivery date, specific relevant expertise and experience, right management experience, and knowledge transfer and training.

The major output of procurement planning is the procurement management plan.

Output of Planning Procurement Management

There is a host of output items generated by this process largely addressing the different aspects of how to perform procurement management.

Make-or-Buy Decision and Source-Selection Criteria

The *source-selection criteria*, generated by the *source-selection analysis* already discussed, guides how to select sellers when buying procurement items. Also called *evaluation criteria*, this is basically developed by the buyer during procurement planning to rate responses from the sellers.

Even before that, *make-or-buy analysis*, already discussed, will generate a *make-or-buy decision* as to whether an item should be made by the project team or be procured.

After selecting an item for procurement, you need a procurement strategy for it.

Procurement Strategy

The purpose of this document is tri-fold:

1. **Determine the Delivery Methods.** The delivery methods depend on the kinds of procurement; e.g.; will subcontracting be allowed for procuring a professional service, or, in the case of procurement in the construction field, what would be the delivery method: build your own operate transfer (BOOT), design build operate (DBO), or turnkey, etc.
2. **Determine Hows of Phase Management.** Hows of sequencing the procurement phases; performance indication and milestones in each phase; monitoring each phase; evaluation and tracking progress; criterion to meet before procurement will go next phase; and knowledge transfer.
3. **Determine the Contract Payment Types.** There are already-discussed contract types, such as lump sum, firm fixed price, cost plus award fees, cost plus incentive fees, and so on.

After we have decided to procure an item, or items, and have some strategy in place, we need to start looking for sellers, which requires putting together documents—the bidding documents.

Bidding Documents

This is the set of procurement documents put together during procurement planning. The buyer structures these documents with two goals in mind:

- To facilitate an accurate and complete response from each potential seller
- To facilitate easy evaluation of the responses

These documents include the following:

- A description of the desired form of the response
- A relevant contract statement of work (SOW)
- Any required contractual provisions, such as a copy of a model contract, and non-disclosure provisions

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Tip In government contracting, some or all of the content and structure of a procurement document might already be defined by regulations.

What Are These Documents Called? Different terms are used for these documents for different purposes:

- A term such as *bid*, *tender*, or *quotation* is used when the seller-selection decision will be based on the price when buying commercial or standard items.
- A term such as *proposal* is used when multiple factors are considered, such as cost, technical skills, and technical approach.

What Do These Documents Include? Depending on the kind of procurement, these documents may include the items in Table 12-6.

Table 12-6. Specific Bidding Documents

Document Name	Use
Request for Information (ROI)	Get more information from sellers on the procurement items.
Request for Quotation (ROQ)	Get more information on how the sellers would meet the procurement item requirement; e.g.; price.
Request for Proposal (ROP)	Get more information on how the sellers would solve a given problem.
Statement of Work (SOW)	Can be a part of the preceding documents

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Note These bidding documents travel from buyer to seller, whereas the responses to these, such as bids, quotations, and proposals, travel from seller to buyer.

Statement of Work (SOW) and Term of Reference (TOR). The purpose of SOW is to provide enough information about the procurement item to enable the seller to provide back the completed item. The SOW might change in a back and forth between the buyer and seller until it goes into the contract. It's developed from the portion of the project scope belonging to the procurement item. It describes the item in sufficient detail that the seller will be able to figure out what exactly is wanted. The definition of *sufficient detail* depends upon the specific item, buyer's need, and the contract form. In general, it can include:

- Specification
- Quality level
- Quantity, if applicable
- Performance data
- Performance period
- Work location, if applicable

It should be specific and precise as opposed to vague, and concise yet complete.

The term *Term of Reference* (TOR) is used instead of SOW when the procurement item is a service.

Independent Cost Estimates

During the Conduct Procurement process, sellers will respond to bidding documents with a proposal. How will we know that the price in the proposal is reasonable? The answer is independent cost estimates. Depending on the size and need of the project, an independent cost estimate can be performed for procurement items. The procuring organization prepares the independent estimate in-house or has it done by a third party. They can then use it as a benchmark to evaluate the proposed cost.

How the overall procurement works would be coordinated and integrated with project work; related issues are discussed in the procurement plan.

Procurement Management Plan

This document describes how the procurement will be managed throughout the project. Depending on the project need, it can be brief or detailed, informal or formal. The plan may include the following:

- How the make-or-buy decisions will be made and handled
- **Contracts:**
  - What types of contracts will be used for this project
  - The form and format for the *statement of work* related to a procurement or a contract
  - Metrics to be used to evaluate potential sellers and to manage contracts
  - Requirements for performance bonds or insurance contracts that might be put in place to mitigate some project risks
- **Management and Coordination:**
  - Time table of procurement activities
  - How to manage multiple sellers
  - How to coordinate procurement with other aspects of the project, such as the project schedule, scope, budget, and status progress reporting
  - Evaluation criteria for selecting sellers and measuring their performance; e.g.; source-selection criteria
  - How to handle legal and currency issues
  - Making use of pre-qualified sellers
- A list of assumptions and constraints that could affect the procurement
- Any needed standardized procurement document

Caution! The procurement management plan should describe whether to conduct local, national, or international competitive bidding. If the project is financed externally, make sure the three elements are properly aligned: funding, project schedule, and procurement management plan.

The decision to procure and other decisions that would follow may generate change requests, which will cause the need to update some documents, such as those listed in the output column of Table 12-2.

In a nutshell, the major tasks of procurement planning are 1) perform the *make-or-buy analysis* to make *buy-or-make decisions*; 2) if a procurement decision is made, determine the *procurement strategy*; 3) perform *source-selection analysis* to determine the *source-selection criteria;* 4) prepare bidding documents, including *statement of work (SOW)*, for getting bids and proposals from the sellers, which would be evaluated during the Conduct Procurement process using the *source-selection criteria*; 5) determine other "how-tos" about overall coordinating and integrating procurement work with the project and related issues; and 6) develop procurement plan.

STUDY CHECKPOINT 12.2

In the following table, match each item in the first column to one or more items in the second column.

Document	Include or discuss
A. Procurement management plan	1. Request for information (ROI)
B. Procurement strategy	2. Delivery methods
C. Statement of Work (SOW)	3. Request for quotation (ROQ)
D. Bid documents	4. Integrating procurement with project work
	5. Performance data
	6. Request for proposal (ROP)
	7. Stakeholders' procurement responsibilities
	8. Procurement phase management
	9. Key procurement activities
	10. Contract payment types
	11. Performance period
	12. Work location

With procurement planned out, you are ready to actually conduct the procurements.

Conducting Procurements

As you have already learned, procurement refers to obtaining (purchasing or renting) products, services, or results from outside the project team to complete the project. Procurement management is the execution of a set of processes used to obtain (procure) a procurement item or items. Procurement planning produces the procurement management plan and other documents to facilitate the implementation of this plan. The implementation is largely done in the Conduct Procurement process by seeking out sellers, getting responses from them, selecting sellers, and reaching an agreement with them. Table 12-7 presents the Conduct Procurement process in terms of input, tools and techniques, and output.

Table 12-7. The Conduct Procurement Process: Input, Tools and Techniques, and Output

Input	Tools and Techniques	Output
1. Project Management Plan • Procurement management plan • Scope management plan • Communication management plan • Requirement management plan • Risk management plan • Configuration management plan • Cost baseline 2. Project documents • Project schedule • Requirement documentation • Stakeholder register • Risk register • Lessons learned register 3. Procurement documentation 4. Seller proposals 5. Enterprise environmental factors 6. Organizational project assets	1. Advertising 2. Bidder conferences 3. Data analysis: Proposal evaluation 4. Interpersonal and team skills: Procurement negotiations 5. Expert judgment	1. Selected sellers 2. Agreements 3. Change requests 4. Project Management Plan Update: • Procurement management plan • Communication management plan • Requirement management plan • Risk management plan • Quality management plan • Scope baseline • Schedule baseline • Cost baseline 5. Project documents update: • Resource calendar • Requirement documentation • Requirement traceability matrix • Stakeholder register • Risk register • Lessons learned register 6. Organizational project assets update

In the input column of Table 12-7, item *procurement documents* consists of 1) bid documents; 2) statement of work (SOW); 3) independent cost estimate; and 4) source-selection criteria; all these and the *seller proposals* were discussed in the previous section. All other input items should be familiar by reaching this point in the book.

Core of Conducting Procurements

In this section, we will discuss, in terms of the items from Table 12-7, how to perform the Conduct Procurement process. Let's start by noting that the goal of this process is to secure an agreement with the seller on the procurement item. It's very important to realize that procuring an item is equivalent to procuring, or outsourcing, a piece of your project. In other words, the procurement item has a piece of the project attached to it in terms of its share of scope, requirement, cost baseline, project schedule, stakeholders, and risks. Most of the plan and project documents appearing in the input column of Table 12-7 are carrying information about these aspects of the procurement items; this is why these documents are there. This information was mostly already used in preparing the bidding document and the statement of work (SOW) in the Plan Procurement Management process and travels to sellers that way in this process. In this process, this information would be used for various purposes, such as in evaluating the bids or proposals and negotiating with the sellers; e.g.; cost and schedule should stay aligned with the project cost and schedule baselines.

Also note that some of the information will come from the seller to enter into these documents; e.g.; lessons learned during this process for *lessons learned register* and risks coming from the seller's side for the *risk register*.

The whole process can be summarized in the following steps:

1. **Seek Sellers.** Use suitable means such as *advertising* and *bidder conferences* to seek the sellers and to send the appropriate *bidder documents* including *SOW*.
2. **Select Sellers.** Use the *source-selection criteria*, a *procurement document*, and information from other input documents to evaluate the submitted bids and proposals. In this evaluation, check the proposed cost against that in your *independent cost estimates*, another procurement document. Based on this evaluation, select one or more sellers.
3. **Obtain Agreement.** Use *negotiations* and other communication skills to reach an agreement with one or more of the selected sellers.

Tip If the proposed cost is incompatible with the independent estimate, the possible causes of this mismatch should be examined, which may include the vague or unclear SOW, misunderstanding of SOW by sellers, or simply that seller price is higher than others.

Note Bids and quotations are typically used to ask for prices, whereas proposals are used to ask for solutions. Invitations for bids, requests for quotations, and requests for proposals travel from buyer to seller, whereas bids, quotations, and proposals travel from seller to buyer.

In the following, we will discuss the tools and techniques referred to in this section.

Tools and Techniques for Conducting Procurements

The first goal for the tools and techniques here is to find sellers and provide them with information about the requests for responses. The list of potential sellers can be developed from various sources, such as the World Wide Web, library directories, relevant local associations, trade catalogs, and the performing organization's internal information database.

The main techniques used in soliciting seller responses are advertising and bidder conferences. These and other techniques used in conducting procurements are discussed in the following list.

Advertising. The request for seller responses can be advertised in the public media or in relevant professional journals. Whether to use advertising depends on the organization's policy. However, some government jurisdictions require public advertising of pending government contracts.

Bidder Conferences. This refers to meetings with prospective sellers prior to their preparation of a response to ensure that the sellers have a clear understanding of the procurement, such as the technical and contractual requirements. These meetings can generate amendments to the documents depending on the need. The purpose of these meetings is that all potential sellers receive the same kind of detail and amount of information (or help) so that each seller has an equal opportunity to produce the best response. These conferences are also called *contractor conferences*, *vendor conferences*, or *pre-bid conferences*.

Note In some cases, after a proposal is submitted, the buyer can request that the seller supplement its proposal with an oral presentation to provide some additional information, which can be used to evaluate the seller's proposal.

Proposals submitted by sellers need to be evaluated.

Proposal Evaluation. Using this technique, you will check if a proposal is complete according to the bidding document, including SOW. If it is, evaluate it using the *source-selection criteria* and by comparing the cost to the *independent cost estimates*. As said before, the purpose of independent estimates is to have a check on the pricing proposed by the seller. Significant differences between the proposed cost and the independent estimate may mean vague or unclear SOW, misunderstanding of SOW by sellers, market has changed, or the seller has failed to offer reasonable pricing.

Based on this evaluation, you select one or more sellers. Negotiations are conducted to reach agreements with one or more sellers.

Procurement Negotiations. Procurement negotiations, also called *contract negotiations*, have the following two-pronged goal:

- Clarify the terms of the purchase, such as the structure and the rights and obligations of the parties in the contract
- Reach an agreement

Subjects covered during the negotiations may include the following:

- Applicable terms and laws
- Authorities, rights, and responsibilities
- Business management and technical approaches
- Contract financing
- Payments and price
- Proprietary rights
- Schedule
- Technical solutions

The conclusion of contract negotiations is a document, the contract, which can be signed by both the buyer and the seller. The final contract signed by both parties can be an offer by the seller or a counteroffer by the buyer. Sometimes for simple procurement items the contract is nonnegotiable.

Tip A contract is a mutually binding legal relationship subject to remedy in court. These negotiations are usually conducted by the procurement team. However, the project manager might be required to be present during negotiations to provide any necessary clarification on the project requirements.

Expert judgment involves other tools that can also be used during conducting procurements.

Output of Conducting Procurements

The main outputs of conducting procurements include the list of selected sellers and the agreements with the selected sellers. These and other output items are discussed in the following paragraphs.

Selected Sellers. This is the list of sellers that you or the procurement team have selected as a result of the proposal and bid evaluations. A subset of these sellers would get rewarded a contract.

Agreements. Also called procurement awards, these are the contracts awarded to selected sellers after negotiations. A contract is a legal document that obligates the seller to provide the specified procurement item or items and obligates the buyer to make the payment to the seller. The contract can be a simple purchase order or a complex document, depending on the nature of the procurement. A contract can include the following:

- List of deliverables and statement of work
- Schedule
- Performance reporting
- Acceptance criteria
- Change-request handling
- Inflation adjustments
- Penalties and incentives
- Terms of pricing and payment
- Product support
- Roles and responsibilities
- Termination and dispute-handling mechanisms
- Insurance
- Limitation of liability
- Warranty

Changes and Updates. The activities of this process may generate change requests, which may require the updating of some documents, such as those listed in the output column of Table 12-7.

STUDY CHECKPOINT 12.3

Q. True or False: The main goals of the Conduct Procurements process are select the sellers, award procurement contracts to them, and obtain the procurement item.

Like any other part of the project, you need to monitor and control procurements, which you do by using the Control Procurements process.

Control Procurements

Controlling procurements is the process of ensuring that the performances of the buyer and seller meet the agreed-upon procurement requirements, and that the procurement is properly closed. It includes:

1. Manage procurement-specific relationships.
2. Monitor the performance of the procurement part of the project.
3. Manage the procurement-related changes.
4. Close procurement contracts.

Controlling procurements has a two-pronged goal: ensuring that the seller's performance meets the procurement requirements and that the buyer's meets its agreed-upon contractual obligations. Depending on the size and complexity of the project and the structure of the performing organization, procurement administration may be handled by a group outside of the project organization. But you will still need to integrate the procure function with the project and act as a communicator and coordinator to ensure that this function is performed smoothly without adversely affecting the other aspects of the project. This is accomplished by monitoring and controlling the interface of the procurement processes with non-procurement processes such as those from quality, risk, and integration management. Most of the input and output items in Table 12-8 reflect that interface.

Table 12-8. The Control Procurement Process: Input, Tools and Techniques, and Output

Input	Tools and Techniques	Output
1. Project Management Plan: • Procurement management plan • Change management plan • Requirement management plan • Risk management plan • Schedule baseline 2. Project documents: • Milestones list • Requirement traceability matrix • Requirement documentation • Quality reports • Stakeholder register • Assumptions log • Risk register • Lessons learned register 3. Agreements 4. Procurement documentation 5. Approved change requests 6. Work performance data 7. Enterprise environmental factors 8. Organizational project assets	1. Claims administration 2. Data analysis: • Procurement performance reviews • Earned value analysis • Trend analysis 3. Audits and inspections 4. Expert judgment	1. Closed procurement 2. Work performance information 3. Procurement documentation update 4. Change requests 5. Project Management Plan update: • Procurement management plan • Risk managem ent plan • Schedule baseline • Cost baseline 6. Project documents update: • Resource requirement documentation • Requirement traceability matrix • Stakeholder register • Risk register • Lessons learned register 7. Organizational project assets update

Core of Controlling Procurements

As discussed earlier, procuring an item is equivalent to procuring or outsourcing a piece of your project with its share of scope, requirements, cost baseline, project schedule, stakeholders, and risks. However, this procured piece is still connected to the whole project and can affect and impact it. In this context, the core of controlling procurement is to manage the interface of the procurement processes with the other processes of the project, as mentioned earlier. In this section, we will illustrate how you do that.

The input and output items in Table 12-8 represent the interface you need to manage. From this and other chapters, you are familiar with all these items and their roles. In the following, we explain in a compact manner how to manage this interface.

Manage Information about the Procurement

For this process, information about the procurement seller(s) comes to and is managed by two kinds of documents: 1) documents from procurement processes, e.g.; *agreements*, *procurement documentation*, and *procurement management plan*; and 2) documents from non-procurement processes, such as the following:

- The *milestones list* holds the dates by which sellers must deliver specific results.
- The procurement-related assumptions go into the *assumptions log*.
- The risk from the seller side goes into and is managed by using the *risk register*; risk from the sellers' side may arise from cost, missing a milestone, delivery method, and so on.
- These risks can be managed as guided by the *risk management plan*.
- Procurement-related requirements, both technical that the seller is required to meet and contractual, become part of the *requirement documentation*.
- These requirements are managed as guided by the *requirement management plan.*

Analysis of Sellers' Data

The *work performance data* contains raw performance data from the seller side, such as activities in progress and finished, cost incurred, and so on. As described in Chapter 7, by using *earned value analysis* you will compute the performance indexes and variances for schedule and cost. Comparing these with the agreed-upon planned target, e.g.; SOW, will measure the deviation. Also, as explained in Chapter 7, you can *perform trend analysis* to predict the estimate at completion for cost to monitor cost; e.g.; is it on track, improving, or getting worse?

You can also keep track of the procurement by conducting *performance reviews*, as discussed in Chapter 10. As in any control process, from the seller data you will measure certain quantities about schedule, resources, and cost performance and compare them with their expected values in the contract or agreement or agreed-upon procurement documents.

Perform Audits and Inspections

Discussed in Chapter 10, you can apply these tools here too in a similar way. For example, for an inspection you can perform a structural review of the contractor's work; e.g.; review actual work or final product—i.e., deliverable. Depending on the field, this review can take many forms; e.g.; in software engineering, it could be a code walkthrough.

In this process, the audit would be a structural review of the overall procurement process. The buyer and sellers' project managers should share the results from the audit and make necessary changes.

Create Work Performance Information

Similar to any monitoring and controlling process, data analysis and audit and inspections will generate *work performance information*. In this process, for example, work performance information will include information on how the seller's performance looks in terms of schedule, cost, and technical performance as compared to the SOW.

Generate Change Requests

Some deviations found during data analysis and audit and inspections will generate *change requests*, such as to the procurement management plan, schedule baseline, and cost baseline. As always, change requests are processed through the Perform Integrated Change Control process.

Because there are two parties, buyer and seller, involved in procurement, there may arise disagreements as to whether the deviation or change happened or if the solution to the change is acceptable. The preferred method to resolution would be through negotiations, as may be described in the contract. If negotiations fail, then these changes are called *disputed claims* and are processed through *alternative dispute resolution (ADR)* that may be referred to in the contract. Handling these kinds of changes is called *claim administration*.

Like in any process, change requests and some other actions may require some documents, such as those listed in the output column of Table 12-8, to be updated.

Close Procurements. When you or your team have accepted all the deliverables from the sellers through the Control Procurement process and there are no payments due or unresolved claims, then the procurement team, through an authorized administrator, can formally close the procurement as described in the procurement management plan and the contract. This includes closing all the agreements/contracts.

In a nutshell, you use the Control Procurement process to monitor and control the implication to SOW and the agreement between sellers and buyer, which ends when the seller delivers the procurement items.

The three most important takeaways from this chapter are the following:

1. By using the Plan Procurement Management process, you identify the procurements and potential sellers, prepare procurements, and form a procurement strategy and plan.
2. The procurement strategy and plan are implemented by using the Conduct Procurement and Control Procurements processes.
3. The goal of the Conduct Procurement Process is reaching an agreement between the buyer and the seller; the goal of the Control Procurement process is the delivery the acceptable procurement items by the sellers to the buyer.

Summary

Procurement refers to obtaining—purchasing or renting—items (i.e., products, services, or results) from outside the project team to complete the project. Accordingly, procurement management is performing a set of processes used to plan and obtain (procure) those things from outside the project team needed to complete the project. The party purchasing (procuring) the items is called the buyer, and the party delivering the items to the buyer is called the seller.

Planning procurement is the process of making purchasing decisions on what to procure, identifying potential sellers, determining the strategy, and making the overall plan. Conducting procurement means soliciting seller responses, selecting sellers, and awarding contracts. You administer and close the procurements by controlling the contract execution; i.e., making approved changes and corrections, managing relationships among the parties involved in the procurements, making sure that all acceptable procurement items are delivered by the seller, and ensuring the contracts are closed out. Just like the rest of the project, the procurements need to be closed properly.

In a nutshell, identifying procurement items and potential sellers is the Plan Procurement Management process; reaching an agreement with the seller is the Conduct Procurements process; and obtaining the procurement items in the Control Procurements process.

Road Ahead. The end product of procurement management is the accepted procurement items. The related information is sent to the Close Project process.

Exam's Eye View

Comprehend

- The major tasks of procurement planning include performing the make-or-buy analysis to make buy-or-make decisions; determining procurement strategy; performing source-selection analysis to determine the source-selection criteria; preparing bidding documents, including statement of work (SOW), for getting bids and proposals; and determining other "how-tos" about overall coordinating and integrating procurement work with the project and the related issues; and developing a procurement plan.
- Conducting procurement is a process of obtaining responses from potential sellers, selecting sellers based on those responses, and awarding contracts to the selected sellers.
- Invitations for bids, requests for quotations, and requests for proposals—in other words, bidding documents including SOW—travel from buyer to seller, whereas bids, quotations, and proposals travel from seller to buyer.
- The deliverables are accepted through the procurement closure process and related information in the project closure process.

Look Out

- The proposal, an input of Conduct Procurements, is created during the same process by the seller.
- SOW may be included in the bidding document.
- The contracts are closed using the Control Procurements process.
- The procured deliverables are provided by the sellers during this process before the procurement is closed.

Memorize

- Procurement documents consist of 1) bid documents; 2) statement of work (SOW); 3) independent cost estimate; and 4) source-selection criteria
- Bidding consists of request for information (ROI), request for quotation (ROQ), and request for proposal (ROP). It may include SOW.
- In procurement, a term such as *bid*, *tender*, or *quotation* is used when the seller-selection decision will be based on the price when buying commercial or standard items; whereas a term such as *proposal* is used when multiple factors are considered, such as cost, technical skills, and technical approach.

Review Questions

1. You are a project manager at a company that is a seller for another company. You are coordinating the efforts to bid on a contract with another company to sell the product of your company. Which of the following contract types carries the most risk for your company?

   A. CPIF

   B. T&M

   C. CPFF

   D. FFP

2. Ron Collins is the project manager for a biotechnology company. He is outsourcing a part of the project to a foreign company. The foreign company will charge Ron $10 per hour for each employee that will be involved in the outsourced part of the project. Ron will also be charged an extra amount of $100 per month for other charges, such as using the facilities for the duration of the project. What type of contract is it?

   A. T&M

   B. FP

   C. CPPC

   D. CPIF

3. Which of the following is not true about planning procurements?

   A. Scope baseline is an input to planning procurements.

   B. SOW is an input to planning procurements.

   C. Make-or-buy decisions are an output of planning procurements.

   D. Project charter is an output of planning procurements.

4. In procurement, which of the following contract types presents the highest risk for the buyer?

   A. Firm fixed price

   B. Cost plus fixed fee

   C. Cost plus percentage of cost

   D. Cost plus incentive fee

5. You are managing a software project. The project is already in the execution stage when you discover that a whole software module is missing from the work breakdown structure (WBS). Your company does not have the programmers to write the module in a timely fashion, so you decide to procure this piece of work. The module will have a number of small programs working together, and it will take almost the same effort to write any of these programs. The software experts have given you an estimate of how much that effort will be. However, it is not clear at this stage how many programs will be needed. Which type of contract will you choose in this situation?

   A. Time and material

   B. Cost plus fixed fee

   C. Cost plus percentage of cost

   D. Firm fixed price

6. The analysis to make a buy-or-make decision is performed during which of the following procurement process?

   A. Conduct Procurements

   B. Administer Procurement

   C. Plan Procurements

   D. Control Procurement

7. Your company is outsourcing a part of your project and therefore is preparing the procurement documents. Which of the following is not a bidding document?

   A. Request for information (ROI)

   B. Request for quotation (ROQ)

   C. Request for proposal (ROP)

   D. Seller proposal

8. Your organization is playing the seller role in doing a part of a project for another company, the buyer. The buyer has incomplete specifications for the work involved at this stage and wants you to start the work after signing the agreement. Which of the following contract types will be the most beneficial for your organization?

   A. Fixed price

   B. Time and material

   C. Cost plus percentage of cost

   D. Cost plus time

9. Which of the following is the correct order in which to perform the listed processes for the first time?

   A. Direct and Manage Project Work, Control Procurements, Perform Integrated Change Control

   B. Control Procurements, Perform Integrated Change Control, Direct and Manage Project Work

   C. Perform Integrated Change Control, Control Procurements, Direct and Manage Project Work

   D. Perform Integrated Change Control, Direct and Manage Project Work, Control Procurements

10. Which of the following is not an activity of the Control Procurements process?

   A. Issuing formal acceptance of the procured products

   B. Handing over the accepted products to the appropriate parties, such as the customer or the sponsor

   C. Closing all the contracts associated with the procurement

   D. Archiving lessons-learned documents

11. You are in the process of closing the Stem Cells Are Us project. Which of the following is not an output of the Close Project or Phase process?

   A. Lessons learned archived

   B. Products handed over to costumers

   C. Closed procurement contracts

   D. Final project report written

12. Which of the following is the correct order of performing processes?

    A. Validate Scope, Quality Control, Close Project or Phase

    B. Quality Control, Validate Scope, Close Project or Phase

    C. Validate Scope, Close Project or Phase, Control Procurements

    D. Quality Control, Close Project or Phase, Control Procurements

    E. Close Project or Phase, Validate Scope

13. The seller proposals, an input item for Conduct Procurements, is created during which process?

    A. Conduct Procurements

    B. Plan Procurements

    C. Control Procurements

    D. Close Procurements

APPENDIX

A

Answers to Study Checkpoint Exercises

Chapter 1

STUDY CHECKPOINT 1.1

Identify each of the following items as a project or an operation.

A. A librarian performing her daily job responsibilities

B. A bookseller processing customer orders

C. A network administrator ensuring that the network stays up and running 24/7

D. Taking a course in molecular biology

Answers: A, B, and C are examples of operations: ongoing and repetitive efforts. D is a project with a definitive amount of effort (a beginning and an end) and a unique product or result, such as grades.

P. Sanghera, *CAPM® in Depth*, https://doi.org/10.1007/978-1-4842-3664-2

STUDY CHECKPOINT 1.2

What is the core difference between knowledge areas and process groups? Try to answer this question in one sentence.

Answer: Knowledge areas are disciplines of management that represent management knowledge of a certain topic, such as cost and time, whereas process groups are about the application of that knowledge—that is, where and when to apply that knowledge; for example, during initiating or during planning, and so on.

Okay, that was a long sentence. Here is the short answer: Knowledge areas are about knowledge of project management topics, and process groups are about applying that knowledge.

STUDY CHECKPOINT 1.3

In the following table, match each item in the first column with a corresponding item in the second column:

Knowledge Area	Action
A. Message	1. While developing the schedule, Lora realized that there was a risk involved in the project. So, she put her thoughts into a note that she wrote on her computer.
B. Scope	2. Manage interdependencies among different processes belonging to different knowledge areas.
C. Cost	3. Ensure the project includes the work required to complete the project successfully and no extra work.
D. Schedule	4. Plan the schedule and complete the project within the planned schedule.
E. Quality	5. Plan the budget, track what you are spending, and complete the project within budget.
F. Risk	6. Ensure that you develop the right product that will satisfy the needs for which the project is undertaken.
G. Procurement	7. Obtain the team to do the project work and lead and motivate the team to keep working in the right direction in an efficient and effective way.
H. Resources	8. Generate and distribute the required project information to the right stakeholders at the right time by using the right method.
I. Communication	9. Plan for uncertain events that could happen and deal with them when they do happen in such a way that possible benefit is maximized and damage is minimized.
J. Integration	10. Identify the project work that needs to be contracted out of the performing organization and contract it out.

Answers:

A. 1
B. 3
C. 5
D. 4
E. 6
F. 9
G. 10
H. 7
I. 8
J. 2

STUDY CHECKPOINT 1.4

Match each item in the first column of the following table with one or more suitable items in the second column.

Entity	May Contain
A. Project	1. Operations
B. Program	2. Projects
C. Portfolio	3. Programs
	4. Portfolios
	5. Activities to create a well-defined unique product

Answers:

A. 5
B. 2, 3
C. 1, 2, 3, 4

STUDY CHECKPOINT 1.5

You are about to throw a quarter and a dime several times. What is the probability of the following happening?

A. The quarter will land heads up on the first try.

B. The dime will land tails up on the first try.

C. The quarter will land heads up and the dime will land tails up on the first try.

D. Both the quarter and the dime will land heads up on the first try.

E. The quarter will land heads up on the first try and also heads up on the second try.

Answers: The quarter has a probability of 0.5 to land either way: heads up or tails up. The same is true for the dime.

Considering that, the answers to A and B are 0.5, and the answers to C, D, and E are 0.25 (0.5 X 0.5 = 0.25).

STUDY CHECKPOINT 1.6

In the following table, match each item in the first column to the corresponding item in the second column.

Project Variable	Value
A. Level of staff	1. Highest in the beginning and end of the project and lowest when the project is being executed
B. Risk	2. Highest in the beginning and decreases as the project progresses
C. Ability to influence the characteristics of the project product without significantly impacting the project cost	3. Low in the beginning, maximum when the project is being executed
D. Cost	4. Uniform throughout the project

Answers:

A. 3

B. 2

C. 2

D. 3

Chapter 2

STUDY CHECKPOINT 2.1

Q1. From the organization's perspective, what is the core difference between enterprise environmental factors and organizational process assets?

Q2. In the following table, match each item in the first column to items in the second column.

Factor and Asset Categories	Factor or Asset Examples
Internal factor	A. Company's email system
	B. Check list
External factor	C. City laws where company is
Processes and procedures	D. Configuration management system
	E. An approved external provider
Knowledge databases	F. Commercial risk database
	G. Interest rate
	H. Configuration repository from past projects of the company.

Q1 Answer: Enterprise environmental factors are about how the performing organization does its business, whereas organizational process assets are about how the organization runs its projects.

Explanation: Enterprise environmental factors are the factors of the overall environment in which the organization is operating and doing its business. Organizational process assets are the process-related assets, and the projects are made of processes; therefore, the organizational process assets speak more to how the organization performs its projects.

Q2 Answer: Internal factor: A, E, D; External factor: C, F, G; Processes and procedures: B; Knowledge databases: H

Explanation: Note that a configuration management system (D) is software used in the company, so it's an internal factor, and the configuration repository from past projects of the company (H) belongs to company's knowledge databases.

STUDY CHECKPOINT 2.2

You have been offered a Project B that will earn you a profit of $100,000 in three months. You already have an offer of a Project A that will earn you a profit of $70,000 in three months. You can only do one project during these three months, and the project requesters are unable to move the project durations.

Q1. What is the opportunity cost of Project A?

Q2. What is the opportunity cost of Project B?

Q3. Just based on the opportunity cost, which project will you select?

Q4. Describe what can change your decision based just on the opportunity cost.

Answers:

A1. $100,000, because this is the opportunity that you are missing when you take on Project A.

A2. $70,000, because this is the opportunity that you are missing when you take on Project B.

A3. Project B will be selected because it has a smaller opportunity cost.

A4. Opportunity cost is only one of several criteria that are used to select projects.

It may be that some other criteria, such as a scoring model, will produce different results. You have to see which method is more relevant for your case.

Chapter 3

STUDY CHECKPOINT 3.1

Q1. True or false: It is the responsibility of the project manager to develop the project charter.

Q2. True or false: A project charter is a contract between the performing entity and the entity for which it's being performed.

Q3. Which process project document interfaces the project with the organization's strategy?

Answers:

A1. False. The project manager officially does not even exist when the Develop Project Charter process is started. That said, it's quite possible that a potential project manager may be asked to put together the project charter, or a specific project manager assignment may be part of a bid or a proposal.

A2. False. Project charter is not a contract—e.g.; no money is involved.

A3. Project charter

STUDY CHECKPOINT 3.2

Q1. The performance of a project is measured against which planning element?

Q2. Can you name four baselines?

Answers:

A1. Performance baseline

A2. Scope baseline, schedule baseline, cost baseline, and performance baseline

STUDY CHECKPOINT 3.3

Q1. Many processes in the monitoring and controlling process group generate change requests. Name the process in this process group that is used to approve or reject the change requests.

Q2. Name the processes and other sources that can generate the change requests.

Answers:

A1. Perform Integrated Change Control

A2. Direct and Manage Project Work process, Monitor and Control Project Work process, other processes in the monitor and control process group, and directly from stakeholders.

STUDY CHECKPOINT 3.4

Q1. Name the processes used to generate:

a. Lessons learned register

b. Lessons learned

Q2. For what do we need data analysis during the Close Project process?

Answers:

A1a. Manage Project Knowledge

A1b. Manage Project Knowledge, Close Project or Phase

A2. Data-analysis techniques could be used to analyze the documents, prepare final report, and learn lessons.

STUDY CHECKPOINT 3.5

Q1. What is the first process you perform in managing a project?

Q2. What do you need before you can begin initiating your project?

Answers:

A1. Develop Project Charter

A2. The input to the Develop Project Charter process: business case, project benefit plan, and necessary agreements

Chapter 4

STUDY CHECKPOINT 4.1

Among the following attributes, identify which are part of product scope and which are part of the project scope, according to PMBOK.

A. Develop software modules to support website.

B. The user can only access this website after logging in.

C. The drug should not have more than two side effects.

D. The drug must be developed within one year.

E. The drug must be tested in-house before it goes to the Food and Drug Administration.

Answers:

Project scope: A, D, E

Product scope: B, C

STUDY CHECKPOINT 4.2

Make lists of enterprise environment factors and organizational process assets that can influence the Collect Requirements process.

Answers:

Enterprise environment factors:

Internal: Culture, infrastructure, personnel administration

External: Marking condition, legal restrictions

Organizational process assets: Policies and procedures, organizational and industry standards, knowledge database

STUDY CHECKPOINT 4.3

Assuming that the online learning system in Figure 4-2 is managed by a company with its own teachers:

Q1. Name internal actors

Q2. Name external actors

Answers:

A1. Internal actors: teachers and administration

A2. External actors: students and payment system

STUDY CHECKPOINT 4.4

In the following table, match each item in the first column with an appropriate item in the second column:

A. The software product must run on both Microsoft Windows and Apple Macintosh.	1. Project deliverable
B. An online education website	2. Project constraint
C. The drug must be developed within six months.	3. Product requirement
D. The software module must not have more than 10 bugs.	4. Project management requirement
E. Project manager must have a PMP certification.	5. Product acceptance criteria

Answers:

A. 3

B. 1

C. 2

D. 5

E. 4

STUDY CHECKPOINT 4.5

Q1. What is the difference between management control point and control account?

Q2. What is the difference between control account and code of account?

Answers:

A1. A management control point is a control account.

A2. A code of account is a unique identifier of a work package, and a control account contains one or more work packages—i.e., codes of account—in it.

STUDY CHECKPOINT 4.6

Q1. List some of the organizational process assets that will influence the Control Scope process.

Q2. Why do you need a lessons learned register in the input of the Control Scope process?

Answers:

A1.

1. Policies, procedures, and guidelines related to controlling scope and changes
2. Templates for work performance information
3. Knowledge database of monitoring, controlling, and reporting methods used for previous projects

A2. Lessons learned can be recorded and subsequently applied as the project progresses, and to record the lessons learned from the overall project.

STUDY CHECKPOINT 4.7

Q1. The project scope statement, WBS, and WBS dictionary are used to validate scope. Where are they in Table 4-7?

Q2. The Verify Scope process belongs to which process group?

Q3. From Table 4-7, you know that project documents requirement documentation, requirement traceability matrix, and lessons learned register are updated during the Validate Scope process. Using your knowledge about these documents, what do you think they are updated with in the process?

Q4. Which process will be performed first: quality control or validate scope?

Answers:

A1. The project scope statement, WBS, and WBS dictionary are part of scope baseline listed in Table 4-7.

A2. The Verify Scope process belongs to the monitoring and controlling process group.

A3. Document updated:

1. **Requirement documentation** with validation status such as validated, not validated, requirement waved, and this feature is even than required.
2. **Requirement traceability matrix** with validation status and procedures or methods used in validation.
3. **Lessons learned register** with lessons learned, such as mistakes made and how to avoid them, and which validation methods worked well and which did not. These lessons may be applied the next time the process is run.

A4. The deliverables must be verified using the Control Quality process before they can be processed through the Validate Scope process. So, quality control is usually performed before validate scope, but they can be performed simultaneously as well.

Chapter 5

STUDY CHECKPOINT 5.1

Q1. Using your knowledge of enterprise environmental factors and the plan schedule management process, make a list of EEFs that would influence this process.

Q2. Using your knowledge of organizational project assets and the plan schedule management process, make a list of OPAs that would influence this process.

Answers:

A1. EEFs: Organizational structure and culture; available resources and skills; commercial database—e.g.; standard estimate data; scheduling software tools; and organization's standards or guidelines for tailing the standard schedule-related processes.

A2. OPAs: Schedule-related organizational policies, procedures, forms and templates, monitoring and reporting tools, and lessons learned database from previous projects.

STUDY CHECKPOINT 5.2

Q1. What is the most common logical relationship used in schedule network diagrams?

Q2. What is the least common logical relationship used in schedule network diagrams?

Q3. Make a list of EEFs and OPAs that could influence the process of scheduling activities.

Answers:

A1. Finish to start; i.e., the successor activity cannot be started until the predecessor activity has already been completed.

A2. Start to finish; i.e., the successor activity cannot be completed until the predecessor activity has already been initiated.

A3.

EEFs: Government and industry standards, organization's work authorization system, project management information system (PMIS)

OPAs: Related program and portfolio plans; activity-related organizational policies, procedures, and templates, etc.; and lessons learned database from previous projects

STUDY CHECKPOINT 5.3

Q1. Describe which EEFs can influence the process of estimating activity durations.

Q2. Describe which OPAs can influence the process of estimating activity durations.

Answers:

A1. EEFs: Examples of enterprise environmental factors are some databases that contain the reference data relevant to the activity duration—for instance, how long it takes for a specific government agency to respond to a request. Published commercial information and metrics to measure productivity can also be helpful in duration estimates. The location of team members may also matter; e.g.; due to different local conditions or systems.

A2. OPAs: Organizational process assets that may influence this process include estimating policies; those that are useful in estimating activity duration include information from previous projects and a calendar of working days and non-working days.

STUDY CHECKPOINT 5.4

In the program evaluation and review technique (PERT), the most-likely scenario is given a weight of 4 as compared to the weight of 1 for each of the pessimistic and optimistic scenarios. The pessimistic estimate for an activity is 20 days, the optimistic estimate is 10 days, and the most-likely estimate is 15 days. Calculate the expected estimate using the PERT technique.

Answer:

$t_e = (nt_m+t_o+t_p)/(n+2)$

$= (4X15+10+20)/(4+2)$

$= 90/6 = 15$ days

STUDY CHECKPOINT 5.5

Q1. Describe how assumptions and constraints—e.g.; in the project scope statement—can affect the schedule and what you can do about it.

Q2. List EEFs and OPAs that can influence the process of schedule development.

Answers:

A1. The assumptions and constraints in the project scope statement can affect the project schedule and therefore must be considered in developing the schedule. The following two types of time- and hence schedule-related constraints should get special attention.

- **Hard deadlines on start and finish dates.** Some activities might have constraints on their start or finish dates. For example, there might be a situation in which an activity cannot be started before a certain date, or must be finished before a certain date, or both. Where do these date constraints come from? They can come from various sources, such as a date in the contract, a date determined by the market window, delivery of material from an external vendor, and the like.
- **Time constraints on deliverables.** These constraints can come from the customer, the sponsor, or any other stakeholder in terms of deadlines for certain major deliverables or milestones. Other projects inside or outside your organization might be depending on these constraints. So, once scheduled, these deadlines are constraints and can only be changed through the approval process.

Both assumptions and constraints lead to schedule risk that can be mitigated by applying a *contingency reserve* in the schedule.

A2.

EEFs: Communication channel, e.g.; e-mails and video conferences; scheduling schedule software; and government and industry standards

OPAs: Organizational scheduling methodology or any other schedule-related policy and procedure, project calendars, schedule-related information from previous projects, and a calendar of working days and non-working days.

STUDY CHECKPOINT 5.6

Lora Nirvana is the project manager for the Sequence the DNA of a Buffalo (SDB) project. Match each item in the first column of the following table to the correct item in the second column.

Output of the Develop Schedule Process	Description
A. Schedule data	1. A bar chart that includes all the activities of the project and also includes milestones. Lora points out this bar chart to the project sponsor to show where they are in the execution of the project.
B. Project document updates	2. A bar chart hanging on the calendar that has never changed once it was approved. Lora compares the current bar chart to this bar chart to show the progress.
C. Schedule	3. On a bar chart, Lora points to the dates when she will have the DNA sample isolated and purified, when she will get the DNA sample run through the genetic analyzer, when she will receive the results from the analyzer, and when the results will be published on the Internet.
D. Schedule baseline	4. After realizing that their chosen vendor has a track record of sending the DNA analysis kits late, Lora writes something into the risk register.

Answers:

A. 3

B. 4

C. 1

D. 2

STUDY CHECKPOINT 5.7

Q1. Use your knowledge about the lessons learned register to figure out why we need it as input to the control schedule process.

Q2. Knowing the schedule control process, make a list of organizational process assets that will influence this process.

Answers:

A1. We need the lessons learned register to record the lessons learned and subsequently apply them through the project lifetime.

A2. Schedule control–related organizational policies, procedures, and guidelines; tools; monitoring and reporting methods; and the lessons learned from the historical database, such as:

- The causes of schedule variance
- The reasons for choosing the corrective actions that were taken
- The effectiveness of the corrective actions

Chapter 6

STUDY CHECKPOINT 6.1

Use your knowledge of the Plan Resource Management process to answer to following questions:

Q1. List some EEFs that can influence the Plan Resource Management process.

Q2. List some OPAs that can influence the Plan Resource Management process.

Q3. How can the assumptions log and risk register project documents be updated as a result of this process?

Answers:

The assumptions and constraints in the project scope statement can affect the project schedule and therefore must be considered in developing the schedule. The following two types of time- and hence schedule-related constraints should get special attentions.

Q1. Organizational culture and structure, team and physical resources available within organization, locations of available resources and facilities, and market conditions; e.g.; job market to hire the talent and physical resources

Q2. Organizational human and physical resources, policies and procedures, safety and security policies, template that can be used for resource management planning, and lessons learned and other historical information regarding resource management planning.

Q3. Assumptions log will be updated with changed and new assumptions regarding team and physical resources; e.g.; locations, availability, and requirements. Risk register can be updated with known risks about team and physical resources.

STUDY CHECKPOINT 6.2

Use your knowledge of the Acquire Resources process to answer the following questions:

Q1. List some EEFs that can influence the process of acquiring resources.

Q2. List some OPAs that can influence the process of acquiring resources.

Q3. How are the documents listed for update in the output column of Table 6-6 updated?

Answers:

A1. Organizational culture and structure; market conditions, e.g.; job market to hire the talent and physical resources; and organization's existing physical and human resources with following information:

- Geographical locations
- Availability. It is important to know whether and when the candidate is available before you attempt to obtain that member.
- Competency. Does the candidate have the skills needed to complete the schedule activities?

- Experience. Has the candidate performed similar work well in the past?
- Interests. What is the candidate's interest level in this project and in the work that will be assigned to him or her?
- Cost. What is the cost attached to each candidate in terms of pay? This is even more important if the member is a contractor.

A2. Organizational policies and procedures about acquiring, selecting, and assigning human and physical resources; templates and forms; and lessons learned and other historical information.

A3.

Document	Update Reasons
Resource management plan	Record your experience of obtaining and selecting resources: which technique works the best, etc.
Cost baseline	In actually acquiring and assigning resources, cost and hence cost baseline may change.
Project schedule	May change due to conditions like an or some activities took longer to finish, or the resource availability, etc.
Resource requirements	May change due to change in resource requirements, need for new or different resources, etc.
Resource breakdown structure (RBS)	Obtained and assigned resources need to go into RBS.
Stakeholder register	During this process, new stakeholders will be joining, and information about some old stakeholders may change.
Risk register	New resources, new assignments bring new risks with them.
Lessons learned register	Record your experience of obtaining and selecting resources: which technique works the best, etc.

STUDY CHECKPOINT 6.3

Each comment in the first column of the following table points to a conflict-resolution strategy. Match each comment with the corresponding strategy in the second column.

Comment	Conflict-Resolution Technique
A. Let's have a face-to-face meeting and hear out both parties.	1. Avoidance/withdrawal
B. Both of you have to meet halfway; you can't get everything all the time.	2. Competition/forcing
C. I'm the one who is running the show here, and I have made the decision.	3. Compromising/smoothing
D. OK, I see your point now. I was thinking more at personal level, but your view is more compatible with the project's objectives. I guess for that reason I can live with your approach.	4. Accommodation
E. You guys are not even listening to my argument. I feel I'm wasting my time. So, I'm not going to discuss it with you any longer.	5. Collaboration
F. Let's sit down, talk it out, and design the best solution that is good for all parties.	6. Confronting/problem solving

Answers:

A. 6

B. 3

C. 2

D. 4

E. 1

F. 5

STUDY CHECKPOINT 6.4

Each comment in the first column of the following table points to a management theory in the second column. Match each comment with the corresponding theory in the second column.

Scenario	Motivation Theory
A. The management is real nice to the employees and there are lots of perks. But I'm more concerned about my career path once I join this company.	1. Maslow's Hierarchy of Needs Theory
B. Engineering manager Bob has a habit that employees don't like. Every time he passes by a cubicle of an employee, he peeps at the computer screen over the shoulders of the employee to see what the employee is really doing on the computer.	2. Herzberg's Motivation-Hygiene Theory
C. Rachel Janowicz quit her project management job with the Gugu Gaga company immediately after winning the California super lotto. She said, "Well, my money problem is solved. Now I will do what I always wanted to do."	3. McClelland's Achievement Motivation Theory
D. I'm not going to attend this seminar. Basically, I'll be listening to their pitches all day long. What are the odds that I'll win the door prize?	4. McGregor's X-Y Theory
E. Kushal did not really like the assignment. But he did it anyway because he did not want to let his manager down.	5. Expectancy Theory

Answers:

A. 2

B. 4

C. 1

D. 5

E. 3

STUDY CHECKPOINT 6.5

Using your knowledge of organizational project assets and the Control Resources process, answer the following questions:

Q1. Make a list of OPAs that would influence this process.

Q2. How should the assumptions log and risk register be updated as a result of the Control Resources process?

Answers:

A1. OPAs: Organizational policies and procedures related to controlling resources and resources assignment, and escalation of the issues; lessons learned repository database from previous projects.

A2. *Assumptions log*. Updated with changed or new assumptions about physical resources; e.g.; how costly, efficient, and effective are.

Risk register. Updated with disappeared risk, changed risk levels, and new risks regarding the physical resource quality, price, availability, usage, etc.

Chapter 7

STUDY CHECKPOINT 7.1

Problem: An activity cost estimate goes like this: It will take 20 hours of a programmer's time to write this program. The average rate to hire a programmer is $50 per hour. Therefore, the cost of writing this program, assuming that everything else needed to write the program, such as a computer, is in place, is 20 x $50 = $1,000.

What kind of estimation technique is at work here?

Answer: Parametric estimation

STUDY CHECKPOINT 7.2

The pessimistic cost estimate for an activity is $5,000, the optimistic estimate is $3,000, and the most-likely estimate is $4,000. Calculate the expected estimate by using the PERT technique, where the most-likely scenario is given a weight of 4 as compared to the weight of 1 for each of the pessimistic and optimistic scenarios.

Answer:

$C_e = (nC_m + C_o + C_p) / (n + 2)$

$= (4 X 4000 + 3000 + 5000) / (4 + 2)$

$= 24,000 / 6 = 4,000$

Expected cost estimate = $4,000

STUDY CHECKPOINT 7.3

In our running example, calculate the ETC at the present CPI.

Answer:

$$ETC = \frac{BAC - EV}{CPI} = \frac{\$600,000 - \$150,000}{1.2} = \$375.000$$

Note: CPI was calculated as 1.2 in our running example, earlier in Chapter 7.

STUDY CHECKPOINT 7.4

Prove the validity of the following equation:

EAC = AC + BAC – EV

Answer:

The definition of EAC:

EAC = AC + ETC (1)

The definition of ETC:

ETC = BAC – EV (2)

Substitute the value of ETC from Equation (2) into Equation (1) to obtain:

EAC = AC + BAC – EV

STUDY CHECKPOINT 7.5

In our running example, calculate the EAC at the present CPI.

Answer:

$$EAC = AC + \frac{BAC - EV}{CPI} = \$125.000 + \frac{\$600,000 - \$150,000}{1.2} = \$500.000$$

STUDY CHECKPOINT 7.6

In our running example, calculate the EAC at the present CPI and SPI.

Answer:

$$EAC = AC + \frac{BAC - EV}{CPI \times SPI} = \$125.000 + \frac{\$600,000 - \$150,000}{1.2 * 0.75} = \$625.000$$

Note: SPI is calculated to be 0.75 in our running example from earlier in Chapter 7.

STUDY CHECKPOINT 7.7

Q. Name three processes that convert the work performance data into work performance measurements.

Answer:

A. Control Scope, Control Schedule, and Control Cost

Chapter 8

STUDY CHECKPOINT 8.1

Knowing the Identify Stakeholder process, answer the following:

Q1. Describe which EEFs can influence the Identify Stakeholders process.

Q2. Describe which OPAs can influence the Identify Stakeholders process.

Answers:

A1. Examples of enterprise environmental factors that help identify stakeholders include governmental and industry standards, geographical distribution of facilities and resources, external local culture and trends, organizational cultures, and organizational structure. It's important to understand the organization's culture and structure in order to identify some stakeholders and their possible impact on the project, because different people will have different levels of authority and influence under different cultures and structures, as discussed in Chapter 2.

A2. The stakeholder register templates and the stakeholder registers from previous projects can be useful to create the stakeholder registers for the project at hand. Another example of the organizational process assets helpful in identifying stakeholders is the lessons learned from previous projects. For instance, perhaps you learned from a previous project how you ignored a negative stakeholder, which caused great damage to the project.

STUDY CHECKPOINT 8.2

Knowing the Manage Stakeholder Engagement process, answer the following:

Q1. Describe which EEFs can influence the Manage Stakeholder Engagement process.

Q2. Describe which OPAs can influence the Manage Stakeholder Engagement process.

Answers:

A1. Include geographical distribution of facilities and resources; communication channels; external local culture and trends; organizational cultures, structure, political environment, and personnel policy.

A2. Include the organizational policies and procedures about medial, ethics, security, risk, communications, change management, etc. For effective, efficient stakeholder engagement management, it's important to learn from experience. Therefore, the lessons learned database and historical information are especially useful.

STUDY CHECKPOINT 8.3

True or False: A stakeholder is proposing something that is not within the planned scope of the project. The appropriate response to this proposal is to oppose it.

Answer: False. A project manager is not a de facto opponent to change; instead, you should be an agent *for* change. Your response should be to evaluate the change for its effects on the project and then put it through the approval process, where it may be either rejected or selected.

STUDY CHECKPOINT 8.4

Knowing the Monitor Stakeholder Engagement process, answer the following:

Q1. How will the stakeholder register and risk register be updated as a result of this process?

Q2. How will the stakeholder engagement plan, communications management plan, and resource management plan be updated as a result of this process?

Answers:

A1. The stakeholder register will be updated with any change in stakeholder information such as assessment or classification; and the risk register will be updated with changed risk status as a result of change request implementation.

A2. The stakeholders' engagement plan may be updated with changes in engagement strategy, and accordingly the communications management plan will be updated with change in communication strategies, and the resource management plan with change in team members' responsibilities regarding the stakeholder engagement.

Chapter 9

STUDY CHECKPOINT 9.1

Saira Bano is the project manager for the Sequence the DNA of a Buffalo (SDB) project. Match each item in the first column of the following table to the correct item in the second column.

Term	Action
A. Message	1. While developing the schedule, Saira realized that there was a risk involved in the project. So, she put her thoughts into a note that she wrote on her computer.
B. Medium	2. She sent the note to the project sponsor.
C. Encode	3. She used e-mail to send the message.
D. Noise	4. The sponsor received the message.
E. Receiver	5. The sponsor could not understand some of the acronyms and terms in the e-mail message, such as variable number of tandem repeats (VNTR), central dogma of molecular biology.
F. Feedback	6. The sponsor responded to Saira, expressing his concern that he could not exactly understand her concerns.

Answers:

A. 2

B. 3

C. 1

D. 5

E. 4

F. 6

STUDY CHECKPOINT 9.2

Knowing the Plan Communication Management process, answer the following:

Q1. Describe which EEFs can influence this process.

Q2. Describe which OPAs can influence this process.

Q3. Describe how the documents listed in the output column of Figure 9-2 will be updated.

Answers:

As you are planning to communicate with project stakeholders, the EEFs and OPAs that influence this process are very similar to those that influence the Plan Stakeholder Engagement process.

A1. Examples of enterprise environmental factors that will influence this process include geographical distribution of facilities and resources; communication channels and tools; external local culture and trends; organizational cultures, structure, political environment, personnel policy, and risk threshold.

A2. Examples of organizational process assets include the organizational policies and procedures about medial, ethics, security, risk, communications, change data management, etc.; as well as guidelines to develop, store, retrieve, and distribute information. For effective, efficient stakeholder communication, it's important to learn from experience. Therefore, the lessons learned database and historical information are especially useful.

A3. The components of the project management plan can be updated with communication planning–related changes, such as the communication management plan and stakeholder engagement plan. Communication activities may result in changes in project schedule, and changes in communication planning may result in the need to make changes in stakeholder register; e.g.; requirements of a stakeholder have changed.

STUDY CHECKPOINT 9.3

Q1. Knowing the Manage Communication process, how do you think documents listed for update in Table 9-3 would be updated?

Q2. Why do you need the project stakeholder engagement plan for performing the manage communication process?

Answers:

A1. *Communications management plan* would be updated due to change in communication approach, and *stakeholder engagement plan* due to changes in communication strategies or requirements. Accommodating communication activities may change the *project schedule*. Arising communication issues and risks will generate the need to update *issues log* and *risk register*.

You will also be updating the *lessons learned register* with lessons learned from performing this process to subsequently use it to perform this process more effectively and efficiently.

A2. Because the project stakeholder engagement plan describes how to use stakeholder communication strategies to engage the stakeholder with the project.

STUDY CHECKPOINT 9.4

In the following table, match each item in the first column to one or more items in the second column in the context of its role in communication management.

Item	Role
A. Work performance data	1. Input to Monitor and Control Project Work
B. Work performance information	2. Output of Monitor Communication
C. Work performance reports	3. Output of Monitor and Control Project Work
D. Project communications	4. Output of Direct and Manage Project Work
	5. Input to Monitor Communication
	6. Input to Manage Communication
	7. Output of Manage Communication

Answers:

A. 4, 5

B. 1, 2

C. 3, 6

D. 5, 7

Chapter 10

STUDY CHECKPOINT 10.1

You are trying out a Monte Carlo simulation program that estimates the value of a parameter by using some random variables. You know through the data that the exact value should be 40. You ran the program three times, and it gave you three values: 50, 51, and 52. Based on these values, answer the following questions:

Q1. How precise is the program in making the estimates?

Q2. How accurate are the estimates?

Q3. Are the values generated by the program more accurate or more precise?

Answers:

A1. The program is quite precise because the values 50, 51, and 52 are very close to each other.

Average value = 51

% uncertainty = [(52–50)/51] X 100% = 3.9%

A2. The estimates are far away from the true value, and therefore accuracy is not very good.

Average % deviation = [(51–40)/40] X 100% = 27.5%

A3. Comparing the errors in Parts A and B, the results are more precise and less accurate.

STUDY CHECKPOINT 10.2

Knowing the Plan Quality Management process, answer the following:

Q1. Describe which EEFs can influence this process.

Q2. Describe which OPAs can influence this process.

Q3. Describe how the documents listed in the output column of Figure 10-2 will be updated.

Answers:

As you are planning to communicate with project stakeholders, the EEF and OPA that influence this process are very similar to those that influences the plan stakeholder engagement process.

A1. Examples of enterprise environmental factors that will influence this process include organizational structure; government agencies' regulations; rules, guidelines, and standards of the project's application area; geographical distribution of facilities and resources; inside and outside culture; market conditions; working and operational conditions of project and its deliverables.

A2. Organizational process assets include the organizational quality management system including policies, procedures, guidelines; quality templates including traceability matrix and check sheets; and quality-related lessons learned from historical database.

A3. *Risk management plan* may need to be updated because quality management approach might cause changes in approach to risk management. The addition of quality requirements to WBS dictionary will change project scope baseline, and addition of quality requirements will also update *require traceability matrix.*

As usual, *lessons learned register* is updated with lessons learned, in this case lessons related to quality planning, to be used in the next process run. New risks discovered will update the *risk register. Stakeholder register* is updated with new information found during this process about new and existing stakeholders.

STUDY CHECKPOINT 10.3

Name the processes that will use quality reports as input.

Answer: Monitor and Control Project Work, Close Project or Phase, Validate Scope, Manage Communications, Control Procurements

STUDY CHECKPOINT 10.4

Knowing the Manage Quality process, answer the following:

Q1. List the organizational process assets that can influence this process.

Q2. Which component or components of the project management plan, out of the ones listed in the output column of Table 10-3, will need to be modified as a result of quality activities?

Q3. Which component or components of the project management plan, out of the ones listed in the output column of Table 10-3, will need to be modified as a result of actual results from project execution?

Answers:

A1. Organizational process assets include the organizational quality management system, including policies, procedures, guidelines; quality templates including traceability matrix and check sheets; results from previous audits; and quality-related lessons learned from historical database.

A2. Scope baseline, schedule baseline, cost baseline

A3. Approach to managing quality in *quality management plan*

STUDY CHECKPOINT 10.5

Q1. Which quality process generates quality control measurements?

Q2. Which quality process uses quality control measurements?

Q3. Which quality process generates quality metrics?

Q4. Which quality process uses quality metrics?

Answers:

A1. Control Quality

A2. Manage Quality

A3. Plan Quality

A4. Manage Quality and Control Quality

STUDY CHECKPOINT 10.6

Match every item in the first column of the following table to the items in the second column.

Data presentation tool	A Use
A. Flowchart	1. To identify the most important area of causes of defects
B. Tally sheets	2. To find the relationship between two variables, and find potential causes of defects
C. Scatter diagram	3. To anticipate what quality problems might be and where they might occur
D. Histogram	4. To monitor whether the variance of a specified variable is within the acceptable limits.
E. Affinity diagrams	5. To find frequency of defects
F. Control chart	6. To explore all the potential causes of a problem, not just the obvious ones
G. Cause and effect diagram	**7.** To display the relative importance of different variables, e.g.; is causes

Answers:

A: 3

B: 5

C: 2

D: 7

E: 1

F: 4

G: 6

STUDY CHECKPOINT 10.7

Match every item in the first column of the following table to the items in the second column. An item in first column may match with more than one items in second column and vice versa.

Item	Appears In
A. Quality metrics	1. Input to plan quality management
B. Quality control measurements	2. Input to plan quality
C. Quality report	3. Input to control quality
D. Test and evaluation documents	4. Output of plan quality management
E. Approved change requests	5. Output of manage quality
F. Work performance data	6. Output of control quality
G. Deliverables	7. Input to monitor and control project work
H. Verified deliverables	8. Output of perform integrated change control
I. Work performance information	9. Output of direct and manage project work
J. Change requests	10. Monitor and control project work

Answers:

A: 2, 3, 4

B: 2, 6

C: 5, 10

D: 3, 5

E: 3, 8

F: 3, 9

G: 3

H: 6

I: 6, 7

J: 5, 6

Chapter 11

STUDY CHECKPOINT 11.1

Problem: Knowing the Identify Risks process, make lists of some EEFs and OPAs that can influence this process.

Answers:

EEFs: The environmental factors internal or external to the performing organization that can influence the project must be considered in the risk identification process. This might include academic and industry studies, published information, benchmarking, and commercial databases.

OPAs: This might include risk-related information from previous projects (the knowledge base) including lessons learned, process controls, and risk-related templates and checklists.

STUDY CHECKPOINT 11.2

Problem: Perform an EMV analysis of the decision tree presented in Figure 11-3 to make a decision about which option to take.

Answer:

Option	Initial Cost	Risk Cost	Probability	EMV for Risk Cost	Total Cost
Update	$50,000	$200,000	40%	0.40 X $200,000 = $80,000	$50,000 + $80,000 = $130,000
Build from scratch	$70,000	$200,000	10%	0.10 X $200,000 = $20,000	$70,000 + $20,000 = $90,000

So, building from scratch is a better option because total cost is less.

STUDY CHECKPOINT 11.3

You are the project manager of a movie project. The first column lists some actions you are taking to deal with risks. Match each item in the first column to one item in the second column of this table.

Action	Risk Response Type
A. One of the scenes is to be shot in a country that has enormous bureaucracy and red tape. They possibly can create roadblocks and make it difficult for you. There is nothing much you can do about it.	1. Avoid
B. The jungle where you are going to shoot a few scenes is a wetland and very hot and humid, and the probability of damage happening to the equipment is very high. So, you have decided to buy insurance to protect you against this possible damage.	2. Accept
C. You have learned that during certain parts of the year, the locals hunt in the jungle in large numbers. So, you have decided not to do the shoot during that part of the year.	3. Exploit
D. Although the movie does not depend on it, it will add a lot of marketing value to the movie if your cameras could capture an endangered species of bird that lives in the jungle. You are choosing the time of year for shooting and taking some other actions to increase the probability that the birds will show up.	4. Share
E. The movie has something to do with Thanksgiving Day. You have allotted some extra resources to ensure that the movie is completed in a timely manner for a release on Thanksgiving Day.	5. Mitigate
F. You have learned that there could be mosquitoes in the area where you are going to shoot. So, you have planned to take plenty of mosquito repellant and other products to prevent mosquito bites.	6. Enhance
G. You know of another movie team that's going to shoot some scenes in the same jungle at a different time of year. You have signed a contract with them to share or trade shots of the endangered bird species.	7. Transfer

Answers:

A. 2

B. 7

C. 1

D. 6

E. 3

F. 5

G. 4

STUDY CHECKPOINT 11.4

Q1. Why do you end up updating the *assumptions log* and *lessons learned register* during the Monitor Risks process?

Q2. The *work performance information,* an output item of the Control Risks process, is an input to which process?

Q3. Which other processes generate *work performance information*?

Answers:

A1. Like any other process where you update these two items, during this process too new assumptions and constraints may appear and old assumptions and constraints may be modified and disappear altogether, giving rise to the need to update the *assumptions log*. The *lessons learned register* is updated with lessons learned so that those lessons can be applied in subsequent runs of the process.

A2. Monitor and Control Project Work

A3. Monitor and control processes in all knowledge areas except project integration management.

Chapter 12

STUDY CHECKPOINT 12.1

Rajinder, the project manager, is now working on procurement planning for a portion of the project. She is looking at all the following options for procuring different pieces. Match each consideration in the first column with the corresponding contract type in the second column of the following table.

Consideration	Contract Type
A. Rajinder will pay $3,000 for the use of the facility and $5,000 per month for the employees working on the procured piece for the duration of work. However, there is a cap of $50,000 for the maximum cost.	1. Fixed price (FP)
B. Rajinder will pay for the cost of labor and a lump sum of $5,000.	2. Time and material (T&M)
C. Rajinder will pay $50,000 to maintain the website for the project for two years.	3. Cost plus fixed fee (CPFF)
D. She will provide $10,000 for developing a software program and an extra $1,000 if fewer than 10 bugs are discovered in the program in the first year of its use.	4. Cost plus percentage of cost (CPIF)

Answers:

A. 2

B. 3

C. 1

D. 4

STUDY CHECKPOINT 12.2

In the following table, match each item in first column to one or more items in the second column.

Document	Include or discuss
A. Procurement management plan	1. Request for information (ROI)
B. Procurement strategy	2. Delivery methods
C. Statement of work (SOW)	3. Request for quotation (ROQ)
D. Bid documents	4. Integrating procurement with project work
	5. Performance data
	6. Request for proposal (ROP)
	7. Stakeholders' procurement responsibilities
	8. Procurement phase management
	9. Key procurement activities
	10. Contract payment types
	11. Performance period
	12. Work location

Answers:

A: 4, 7, 9

B: 2, 8, 10

C: 5, 11, 12

D: 1, 3, 6

STUDY CHECKPOINT 12.3

Q. True or False: The main goals of the Conduct Procurements process are select the sellers, award procurement contracts to them, and obtain the procurement item.

Answer. False. The main goals of the Conduct Procurements process are to select the sellers and award procurement contracts to them. The procurement item is obtained in the Control Procurement process.

APPENDIX

B

Answers and Explanations for Chapter Review Questions

Chapter 1

1. **Answer: D**

   D is the correct answer because the defining characteristics of a project are that it must be temporary (with a start and a finish date) and it must produce a unique (new) product.

   A and **B** are incorrect because it's possible to have a project that will involve only one person, and there could be a project without an individual called the project manager. The only two defining characteristics of a project are that it is temporary and unique.

P. Sanghera, *CAPM® in Depth*, https://doi.org/10.1007/978-1-4842-3664-2

C is incorrect because an operation can have a plan and a budget, too.

2. **Answer: B**

   B is the correct answer because building a library is temporary—that is, it will have a start and a finish date, and it will be a new library.

   A, **C**, and **D** are incorrect because running a donut shop, keeping a network up and running, and running a warehouse are all ongoing operations.

3. **Answer: D**

   D is the correct answer because the names of the five process groups are initiating, planning, executing, monitoring and controlling, and closing.

   A, **B**, and **C** are incorrect because there are no process groups with the names of starting, organizing and preparing, or implementing.

4. **Answer: D**

   D is the correct answer because team management is not a knowledge area itself; this task is part of the knowledge area called resource management.

   A, **B**, and **C** are incorrect because these are three of ten project management knowledge areas.

5. **Answer: A**

   A is the correct and the best answer because the project plan is developed starting from the concept and going through the project management plan.

   B and **C** are incorrect because B includes the project lifecycle and C is the lifecycle. Progressive elaboration does not include the lifecycle of the project; its goal is to plan the project. Because the project planning can develop (or change) throughout the project lifecycle, progressive elaboration can continue through the project lifecycle, but does not include the work of the lifecycle.

6. **Answer: A**

   A is the correct answer because:

   The probability that OTF will deliver = 3/4

   The probability that ST will deliver = 1 – 2/3 = 1/3

   The probability that both will deliver = ¾ X 1/3 = ¼ = 0.25

7. **Answer: B**

   B is the correct answer because it's a false statement. Operations are ongoing and do not have a planned closure or end as a project does.

   A, **C**, and **D** are incorrect answers because these are true statements about both projects and operations.

8. **Answer: B**

   B is the correct answer because it sounds like a group of interrelated projects, which would nicely fit into a program.

   A is an incorrect answer because a project usually has only one project manager.

   C is incorrect because the undertaking is temporary and has a set of unique products.

   D is incorrect because a portfolio may contain both projects and programs, and this conversation is being held at the program level and not at the portfolio level.

9. **Answer: A**

   A is the correct answer because adding parental guide notices is a legal requirement.

   B is incorrect because adding these notices is primarily a legal requirement.

   C and **D** are incorrect because work has nothing to do with product and technology.

10. **Answer: A, B, C**

    A, B, and **C** are correct because they list valid project management areas.

    D is incorrect because project time management is not a valid project management area.

11. **Answer: A**

    A is the correct answer because no processes have been performed in each project.

12. **Answer: C**

    C is the correct answer because every output is either a terminal output or becomes an input to another process.

13. **Answer: A**

    A, and not others, is the correct answer because procurements are conducted using the Conduct Procurement process, which belongs to executing process group.

Chapter 2

1. **Answer: B**

    B is the correct answer because the project-oriented organization provides the greatest authority, high-to-almost full, for the project manager.

    A and **C** are incorrect because the authority of the project manager is none-to-low in a functional organization and low-to-high in a matrix organization.

    D is incorrect because the authority of the project manager is low-to-moderate in a virtual organization.

2. **Answer: A**

    A is the correct answer because the authority of the project manager is none-to-low in a functional organization.

    B and **C** are incorrect because the authority of the project manager is high-to-full in a project-oriented organization and low-to-high in a matrix organization.

    D is incorrect because the authority of the project manager is low-to-moderate in a virtual organization.

3. **Answer: C**

    C is the correct answer because technical project management skills, leadership skills, and strategic and business management skills constitute the PMI talent triangle.

A, **B**, and **D** are incorrect answers because the "IT part of project management skills" is not the same as technical project management skills; strategic and "business management skills" are more than just the knowledge of the business strategy of the organization; and knowledge of the IT part of the company's business is not the same as having strategic and business management skills.

4. **Answer: D**

   D is the correct answer because it belongs to technical project management skills and not to strategic and business management skills.

5. **Answer: A**

   A is the correct answer because the PMO provides high-to-almost full project resource availability for the project manager.

   B is incorrect because the hybrid structure doesn't provide high-to-almost full project resource availability for the project manager.

   C and **D** are incorrect because the multidivisional and organic structures only provide none-to-little project resource availability for the project manager.

6. **Answer: D**

   D is the correct answer because a project manager is responsible for achieving the project objectives regardless of the structure of the organization.

   A, **B**, and **C** are incorrect because the authority of project managers may vary over structures, but the responsibility for meeting the project objectives stays with the project manager.

7. **Answer: C**

   C is the correct answer because environmental factors may have positive or negative impacts on the project; for example, they may expand or constrain project options.

   A and **B** are incorrect because environmental factors may have positive or negative impacts.

D is incorrect because environmental factors are hardly ever neutral—certainly, not all of them. You must be aware of them and try to use them for the success of the project.

8. **Answer: B, C, D**

   B, C, and **D** are all included in technical project management skills.

   A is wrong because technical project management means IT-related only.

9. **Answer: A, D**

   A and **D** are correct because the code of conduct of the performing organization is an internal factor, and so is the geographically distributed virtual team.

   B is incorrect because the code of conduct in a country, or city in this case, is an external factor.

   C is incorrect because standardized cost estimate data is an external factor; just because it's on or being viewed on the company's computer system does not change this fact.

10. **Answer: B and C**

    The two project management business documents are: 1) project business case, and 2) project benefit management plan. The summary of need analysis is included in the project business case, and the project charter is a project management document, but it's not called a business document.

11. **Answer: C**

    The project charter is the only document that is issued to authorize the project. The business case document is only used to authorize the project management activities to continue until the project is finally authorized or disapproved.

12. **Answer: C**

    According to PMBOK, the project sponsor authorizes the project.

Chapter 3

1. **Answer: A**

   A is correct because the management of the performing organization or sponsor issues the project charter.

   B is incorrect because issuing a project charter is the responsibility of the performing organization, and a stakeholder does not even have to be a member of the performing organization.

   C is incorrect because issuing a project charter is the responsibility of the performing organization, and a customer does not even have to be a member of the performing organization.

   D is incorrect because the charter authorizes the project manager and not vice versa.

2. **Answer: B**

   B is the correct answer because the project charter is created by the Develop Project Charter process, the only integration management process in the initiation process group.

   A and **C** are incorrect because the business case and project benefit management plan are inputs to the Develop Project Charter process.

   D is incorrect because there is no standard document called preliminary project scope statement.

3. **Answer: B**

   B is the correct answer because the project charter names the project manager and provides the project manager with the authority to use organizational resources to run the project.

   A is incorrect because the sponsor is not authorized by the project charter; the opposite might be true.

   C and **D** are incorrect because these tasks are performed in the Identify Stakeholders process.

4. **Answer: D**

   D is the correct answer because the project schedule is developed during planning. However, some milestone schedule may be included in the project charter.

   A, **B**, and **C** are incorrect because all these items may be included in the project charter.

5. **Answer: B**

   B is the correct answer because a hard deadline imposed on a project is an example of a constraint. A constraint is a restriction (or a limitation) that can affect the performance of the project.

   A is incorrect because an assumption is a factor that you believe to be true; it is not a condition, such as a hard deadline.

   C is incorrect because a hard deadline tells very little about the actual schedule.

   D is incorrect because a constraint is not a risk, but it can possibly cause a risk.

6. **Answer: B**

   B is correct because assumptions represent uncertainty and hence risk. Assumptions must be validated and analyzed as part of risk management at various stages of the project.

   A is incorrect because assumptions by definition represent uncertainty, and as a project manager, it is your responsibility to validate the assumptions at various stages of the project.

   C is incorrect because it is not the correct definition of assumption.

   D is incorrect because you can start the project with the assumptions. All you have to do is validate them at various stages of the project and analyze them as part of risk management.

7. **Answer: C**

   C is the correct answer because it's not true. This process is performed throughout the project.

   A, B, and **C** are incorrect because these are true statements.

8. **Answer: A**

   A is the correct answer because it's true.

   B is an incorrect answer because the Direct and Manage Project Work process only processes the approved change requests.

   C is an incorrect answer because the Monitor and Control Project Work process generates and does not process the change requests.

   D is an incorrect answer because there is no standard process called the Process Change Requests process.

9. **Answer: A and D**

   A and **D** are the correct answers because both the Manage Project Knowledge and Close Project or Phase processes generate the lessons learned output.

   B and **C** are incorrect because these processes do not produce the lessons learned output.

10. **Answer: A**

    A is the correct answer because deliverables are an output of directing and managing project work, but not accepted deliverables; they still need to go through other processes to get accepted.

    B, **C**, and **D** are incorrect answers because the issues log, work performance data, and change requests are generated by the Direct and Manage Project Work process.

11. **Answer: A**

    A is the correct answer because changes can happen and need to be processed throughout the lifecycle of a project.

    B, **C**, and **D** are incorrect because change requests can be requested by processes spread across the process groups.

12. **Answer: A**

    A is the correct answer because the recommendations for corrective and preventive actions and change requests must be processed through the Perform Integrated Change Control process for approval.

    B, **C**, and **D** are incorrect because changes and recommendations are approved through the Perform Integrated Change Control process.

13. **Answer: B**

    B is the correct answer because approved change requests are implemented through the Direct and Manage Project Work process.

    A is incorrect because project management is performed through processes.

    C is incorrect because the Perform Integrated Change Control process is used to process the change requests, and not to implement them.

    D is incorrect because the Monitor and Control Project Work process generates the change requests and does not implement them.

14. **Answer: B**

    B is the correct answer because performance reports are input into the Perform Integrated Change Control process.

    A and **C** are incorrect because the Monitor and Control Project Work process generates performance reports and does not need them, and performance reports are not input into the Close Project process.

    D is incorrect because there is no standard process with this name.

15. **Answer: D**

    D is the correct answer because no project, small or large or even a cancelled one, should skip the closing stage.

    A, **B**, and **C** are incorrect because no project should skip the closing stage. Each project must go through a proper closure.

16. **Answer: C**

    C is the correct answer because it is the project sponsor who signs the final closure documents and can send the project to closure at any stage of the project.

    A is incorrect because the project manager is responsible for managing all the activities needed to close the project, but the closure must be authorized by the sponsor.

    B and **D** are incorrect because neither the customer nor the functional manager can authorize the project closure according to the standard.

17. **Answer: C**

    C is the correct answer because the project deliverables must be accepted by running them through the Validate Scope process before they can become an input to the Close Project or Phase process.

    A, **B**, and **D** are incorrect because the project management plan is a valid input to the Close Project or Phase process.

Chapter 4

1. **Answer: D**

   D is the correct answer because work packages don't have to appear in the order in which the work will be performed. This sequencing will be done later.

   A, **B**, and **C** are incorrect answers because these are the characteristics of the WBS.

2. **Answer: D**

   D is correct because the project charter is created in the initiation stage and is an input item to creating the requirements documentation and the scope statement.

   A is incorrect because the project charter is an input item to creating the project scope statement.

B is incorrect because the project scope statement is an input item to creating the WBS.

C is incorrect because the project charter is an input to creating the requirements documentation.

3. **Answer: A**

   A is correct because the Create WBS process is used to create the WBS.

   B and **C** are incorrect because there are no standard processes named Project Work process or Develop WBS.

   D is incorrect because project initiating is a process group that includes two processes to develop the project charter and to identify stakeholders.

4. **Answer: B**

   B is correct because the Define Scope process is used to create the project scope statement.

   A is incorrect because the Create WBS process is used to create the WBS.

   C is incorrect because there is no such standard process named Create Project Scope.

   D is incorrect because project initiating is a process group that includes two processes to develop the project charter and to identify stakeholders.

5. **Answer: C**

   C is the correct answer because the Plan Scope Management process also generates the requirement management plan.

   A, **B**, and **D** are incorrect because all these are true statements about the project scope management plan, the other output of the plan scope management process.

6. **Answer: A**

   A is correct because the components in the lowest level of the WBS hierarchy are called *work packages*.

   B is incorrect because a control account might consist of more than one work package.

C is incorrect because if a phase is represented in the WBS, it will be represented at a much higher level.

D is incorrect because a milestone might consist of more than one work package.

7. **Answer: A, B, C, D**

   A, **B**, **C**, and **D** are correct because all of these are included in the project scope statement.

8. **Answer: D**

   D is correct because the scope statement, the WBS document, and the WBS dictionary combined make the scope baseline for the project.

   A is incorrect because the WBS dictionary is missing from the list.

   B is incorrect because you must include the WBS document and the WBS dictionary in the scope baseline.

   C is incorrect because you must include the scope statement and the WBS dictionary in the scope baseline along with the WBS document.

9. **Answer: D**

   D is correct because you, the project manager, create the WBS with help from the project team.

   A is incorrect because the project manager creates the WBS with help from the team.

   B and **C** are incorrect because neither the customer nor the upper management of the performing organization creates the WBS.

10. **Answer: B**

    B is correct because the WBS is not part of the project scope statement; it is an output of the Create WBS process, to which the scope statement is an input item.

    A, **C**, and **D** are incorrect because all these items are parts of the project scope statement.

11. **Answer: C**

    B is the correct answer because the requirement management plan and the scope management plan are the output of the Plan Scope Management process.

    A, **C**, and **D** are incorrect because they are not true statements.

12. **Answer: B**

    B is the correct answer because job shadowing is another name for the observations technique for collecting product requirements, which is a part of the Collect Requirements process.

    A, **C**, and **D** are incorrect because job shadowing is not a standard tool or technique for these processes.

13. **Answer: A, B, C, D**

    A, **B**, **C**, and **D** are correct because requirements documentation is an input to the Define Scope process that generates the project scope statement, the Create WBS process that generates the WBS, and the Control Scope process that generates work-performing information.

14. **Answer: A, B**

    A is a correct answer because the project charter is an input to collecting requirements, and the requirement documentation, an output of collection requirements, is an input to creating the WBS.

    B is correct because the scope and quality depend on requirements, and verified deliverables, an output of Control Quality, is an input to validating the scope.

    C is incorrect because requirements are an input to defining scope.

    D is incorrect because verified deliverables, an output of Control Quality, is an input to validating the scope.

15. **Answer: B**

    B is the correct answer because the control account is the node in the WBS that is used as a control management point where scope, schedule, and cost are integrated for the purpose of monitoring and controlling the performance; e.g.; comparing with earned value.

    A is incorrect because the code of account is the number system used to uniquely identify each work package.

    C and **D** are incorrect because there are no standard terms called management account and performance node to refer to any node in the WBS.

16. **Answer: C**

    C is the correct answer because the correct action here is to find the source of the change requests and process the request through the Perform Integrated Change Control process.

    A is incorrect because you are taking action without doing your homework: investigation.

    B is incorrect because you should not let anyone apply the changes without the changes' having been approved.

    D is incorrect because the correct course of action here is to find out the source of the change request and ensure that the request goes through the approval process.

Chapter 5

1. **Answer: C**

    C is the correct answer because the precedence diagramming method is the most commonly used network diagramming method that can be used in the activity sequencing process to represent any of the four kinds of dependency logical relationships.

    A and **B** are incorrect because CPM and simulations are used in the schedule development process.

D is incorrect because the arrow diagramming method is not a popular method and is not even included in the standard.

2. **Answer: B**

   B is the correct answer because crashing is used to compress the schedule by adding more resources to the project.

   A and **D** are incorrect because the network diagramming method and the sequencing method do not need crashing.

   C is incorrect because crashing does not reduce cost. It may very well increase cost when you commit additional resources.

3. **Answer: A**

   A is the correct answer because there is no room for float times on the critical path.

   B and **C** are incorrect because the critical path controls the finish date only for a given start date and vice versa.

   D is incorrect because the critical path is the longest sequence in time, not the shortest.

4. **Answer: B**

   B is the correct answer because an activity has an external dependency when it relies on factors outside the project.

   A is incorrect because Activity Y has a mandatory dependency on Activity X when Y legally or inherently depends on X. It's possible to track down the tourist even after the season.

   C is incorrect because there is no such dependency called internal.

   D is incorrect because we don't have an internal dependency here.

5. **Answer: B**

   B is the correct answer because finish-to-start dependency means that the successor (B) activity cannot start until the predecessor (A) activity is finished.

   A is incorrect because the start-to-finish relationship means that the successor activity cannot finish until the predecessor activity is started.

   C is incorrect because we do not have enough information to say that this dependency is mandatory.

   D is incorrect because although there is a dependency between two activities, that does not mean they are on the critical path.

6. **Answer: A**

   A is the correct answer because each activity on the critical path has a zero float time, and therefore if an activity is delayed, it will delay the entire project.

   B, **C**, and **D** are incorrect because these are incorrect statements about the activities on the critical path.

7. **Answer: C**

   C is the correct answer because the analogous estimating technique estimates the duration of an activity based on the duration of a similar activity in a previous project.

   A is incorrect because parametric estimating uses parameters such as the productivity rate of the resource assigned to the activity.

   B is incorrect because the individual in this example used the analogous method and not expert judgment, even though he happened to be an expert—we don't know in which field.

   D is incorrect because the Delphi technique is not for the activity duration estimating technique.

8. **Answer: C**

   C is correct because the team member is offering a valid reason for the change, and it does not affect the finish date of the project. However, you must change the schedule to reflect the new duration estimate.

   B is incorrect because you must change the schedule to reflect the new duration estimate that you accepted.

   A is incorrect because you do not need to consult with the functional manager in making this decision because the team member is offering a valid reason for the change and it does not affect the finish date of the project.

   D is incorrect because this change does not qualify to be processed through the Integrated Change Control process.

9. **Answer: A**

   A is the correct answer because float time is the positive difference between the allowed late start date and the early start date of a schedule activity, without changing the schedule finish date.

   B, **C**, and **D** are incorrect because these are not valid terms used to describe delaying an activity without changing the schedule finish date.

10. **Answer: B**

    B is the correct answer because by doing some activities in parallel (fast tracking) you might be able to compress the schedule without adding cost.

    A is incorrect because crashing usually results in increased cost because it involves adding extra resources.

    C is incorrect because the project sponsor is sponsoring (paying for) the project. So, asking for a new sponsor does not make sense; it can only trigger the sponsor to ask for a new project manager.

    D is incorrect because you do not want to bypass the sponsor on budgetary matters, because the budget will need the sponsor's approval.

11. **Answer: C**

    C is the correct answer because it has the longest sequence: 8 + 6 + 8 = 22.

    A is incorrect because this path is only 20 units long.

    B is incorrect because there is no such path as Start-I-G-E-Finish in this network diagram.

    D is incorrect because this path is only 21 units long, which is less than 22.

12. **Answer: D**

    D is the correct answer because the float time for G is zero since it is on the critical path.

    A, **B**, and **C** are incorrect because G is on the critical path and must have a float time of zero.

13. **Answer: C**

    C is the correct answer because if you consider all the paths in the network diagram, the path Start-I-G-H-Finish adds up to 22, which is longer than any other path in the diagram.

    A, **B**, and **D** are incorrect because the length of a path is not measured by the number of nodes in it.

14. **Answer: B**

    B is the correct answer because in the three-point method, in this case, using the weighted average is: $(9 + 18 + 4 \times 12)1/6 = 12.5$.

    A is incorrect because a weight of 4 is assigned to the most-likely scenario as compared to the weight of 1 for each of the optimistic and pessimistic scenarios.

    C and **D** are incorrect because the duration estimate should be the weighted average of the three points.

15. **Answer: B**

    B is the correct answer because the activity duration is calculated after an activity has been defined.

    A, **C**, and **D** are incorrect because the WBS, project scope statement, and WBS dictionary (as parts of the scope baseline) are valid input items to the Define Activities process.

16. **Answer: D**

    D is the correct answer because work performance data is an input to this process, and not an output.

    A, **B**, and **C** are incorrect because all these items could be parts of the output of the Schedule Control process.

17. **Answer: C**

    C is the correct answer because the project charter is an input to only one schedule management process, and that is Plan Schedule Management.

    A, **B**, and **D** are incorrect answers because the project charter is an input to only one schedule management process, and that is Plan Schedule Management.

Chapter 6

1. **Answer: D**

   D is the correct answer because a chart that displays the resource assignments for each activity is an example of a responsibility assignment matrix (RAM).

   A is incorrect because a project organization chart represents the relationships between the different roles in the project, and that is not what management wants.

   B is incorrect because the WBS contains work packages, not activities and resource requirements.

   C is incorrect because management wants the resource requirements for each activity, not just a list of roles and responsibilities.

2. **Answer: C**

   C is the correct answer because resource requirement is not the output of the plan resource management process.

   A, **B**, and **D** are incorrect because all these items are the output of the resource planning process.

3. **Answer: C**

   C is the correct answer because the team charter is an output of the resource plan resources process.

   A, **B**, and **D** are incorrect because these are false statements about the team charter document.

4. **Answer: D**

   D is the correct answer because collaboration offers a win–win resolution. Remember that a variation of collaboration is also called *confronting/problem solving*. If that was one of the options instead of collaboration, then that would be the answer.

   A is incorrect because avoidance ignores the problem rather than solving it.

   B is incorrect because in compromising, both parties give up something and might look at the resolution as a lose–lose proposition.

   C is incorrect because accommodation offers a win–lose resolution; one party gives up something to accommodate the interests of the other party.

5. **Answer: D**

   D is the correct answer because you are forcing your way on the other party.

   A and **B** are incorrect because you are neither ignoring the problem nor compromising.

   C is incorrect because you are not accommodating the other side.

6. **Answer: D**

   D is the correct answer because change in budget has very little to do directly with team development.

   A and **B** are incorrect answers because the project kickoff meeting is an indirect method to start team development, and effective resolution of a conflict does contribute to team building.

   C is also incorrect because during times when the team is in a low-morale mode, you should be able to lift the team morale and thereby contribute to team development.

7. **Answer: C**

   C is the correct answer because staff assignments are an output of the Acquire Project Team process.

   A is incorrect because the resource management plan contains roles and responsibilities and not all the staff assignments.

   B is incorrect because staff assignments are an input to the Develop Project Team process.

   D is incorrect because there is no standard process named Make Staff Assignments.

8. **Answer: C**

   C is the correct answer because a virtual team is one of the options, depending on the project, when you are acquiring the team.

   A, **B**, and **D** are incorrect answers because virtual teams are a tool in acquiring the team.

9. **Answer: B**

   B is the correct answer because the term *soft skills* refers to interpersonal skills.

   A, **C**, and **D** are incorrect because these skills are not referred to as soft skills.

10. **Answer: A**

    A is the correct answer because the Survey technique is a data-gathering technique used by experts to reach consensus on a topic. However, in acquiring a team, you want to use all the influence and negotiations at your disposal to get the best team.

    B, **C**, and **D** are incorrect because these are valid techniques to be used for acquiring the team

11. **Answer: B**

    B is the correct answer because Theory X managers think that employees dislike their work and will try to avoid it.

    A is incorrect because there is no standard management theory called Theory Alpha.

C is incorrect because Theory Y managers trust their employees.

D is incorrect because McClelland's theory states that the need for achievement, affiliation, and power motivates employees.

12. **Answer: C**

C is the correct answer because Theory Y managers trust their employees.

A is incorrect because there is no standard management theory called Theory Alpha.

B is incorrect because Theory X managers think that employees dislike their work and will try to avoid it.

D is incorrect because McClelland's theory states that the need for achievement, affiliation, and power motivates employees. C is the more appropriate answer in this case.

13. **Answer: D**

D is the correct answer because McClelland's theory states that the need for achievement, affiliation, and power motivates employees.

A is incorrect because there is no standard management theory called Theory Alpha.

B is incorrect because Theory X managers think that employees dislike their work and will try to avoid it.

C is incorrect because Theory Y managers trust their employees. D is the more appropriate answer in this case.

14. **Answer: B**

B is the correct answer because Control Resources is used to synchronize planned, allotted, and used resources.

A and **D** are incorrect answers because the Control Resources process is used to synchronize planned, allotted, and used resources.

C is incorrect because there is no standard process named Manage Resources.

Chapter 7

1. **Answer: B**

   B is the correct answer because you need resources figured out before you can estimate costs.

   A and **C** are incorrect because you cannot estimate costs until you have a resource plan to figure out resources, and you cannot determine budget until you have cost estimates.

   D is incorrect because you need resources figured out before you can plan for costs management.

2. **Answer: A**

   A is the correct answer, and the other answers are incorrect, because the activity source needs to be known before you can estimate the activity duration to schedule; and resources and schedule need to be known for estimating costs and determining budget.

3. **Answer: A**

   A is the correct answer because the contingency reserve is applied both to activity durations (time) and cost estimates.

   B, **C**, and **D** are incorrect answers because these are true statements about the contingency reserve.

4. **Answer: A**

   A is the correct answer because the cost baseline is an output of the Determine Budget process.

   B is incorrect because there is no standard process with this name.

   C is incorrect because the Estimate Costs process is used to estimate the costs, and these estimates need to be aggregated to determine the budget.

   D is incorrect because cost baseline is an input to the Control Cost process.

5. **Answer: B**

   B is the correct answer because the formula for earned value is: EV = BAC X (work completed/total work required), which means

EV = \$600,000 X (5 miles / 15 miles) = \$200,000

A is incorrect because \$160,000 is the actual cost (AC) and not the earned value (EV).

C is incorrect because earned value is proportional to the fraction of work performed and not the fraction of time passed.

D is incorrect because \$600,000 is the budget at completion (BAC), not the EV.

6. **Answer: C**

C is the correct answer because the formula for planned value is: PV = BAC X (time passed / total schedule time), which means PV = \$600,000 X (3 weeks / 12 weeks) = \$150,000

A is incorrect because \$160,000 is the actual cost (AC) and not the planned value (EV).

B is incorrect because planned value is proportional to the fraction of time passed, not the fraction of work performed.

D is incorrect because \$600,000 is the budget at completion (BAC), not the PV.

7. **Answer: A**

A is the correct answer because the formula for cost variance is: CV = EV – AC,

which means

CV = \$200,000 – \$160,000 = \$40,000

B is incorrect because CV is equal to EV – AC, not EV – PV.

C is incorrect because it calculates the total cost for 12 weeks based on AC for three weeks and then subtracts it from BAC, which is the wrong method to calculate CV.

D is incorrect because it calculates the total cost for 15 miles based on AC for five miles and then subtracts it from BAC, which is the wrong method to calculate CV.

8. **Answer: B**

   B is the correct answer because the formula for schedule variance is: SV = EV – PV, which means SV = $200,000 – $150,000 = $50,000

   A is incorrect because SV is equal to EV – PV, not EV – AC.

   C and **D** are incorrect because SV is measured in units of cost, not in units of time.

9. **Answer: B**

   B is the correct answer because a CPI value greater than one means the cost performance of the project is better than planned, and an SPI value of greater than one means the schedule performance of the project is better than planned.

   A, **C**, and **D** are incorrect because a CPI value greater than one means the cost performance of the project is better than planned, and an SPI value of greater than one means the schedule performance of the project is better than planned.

10. **Answer: D**

    D is the correct answer and **B** is incorrect because the integrated performance measurement baseline refers to schedule baseline, scope baseline, and cost baseline.

    A and **C** are incorrect because there is no time baseline.

11. **Answer: C**

    C is the correct answer and the others are wrong because cost, scope, and schedule are tightly bound and thus affect each other.

12. **Answer: B**

    B is the correct answer because controlling scope, schedule, and cost generates work performance information.

A is incorrect because the Monitor and Control Project Work process is used to generate performance reports and uses work performance information as input.

C is incorrect because there is no standard process with name Develop Project Work Performance Report.

D is incorrect because the Direct and Manage Project Work process does not generate work performance information; it generates work performance data instead.

13. **Answer: A**

    ±10% accuracy leads to an uncertainty of ±\$500 x 10 / 100 = ±\$50

    Therefore, Range = \$450 – \$550

14. **Answer: D**

    D is the correct answer and the others are not because the project charter, schedule management plan, and risk management plan are listed as input to the Plan Cost Management process in PMBOK and the quality management plan is not.

Chapter 8

1. **Answer: B**

   B is correct, and others are incorrect, because stakeholder cube is the right model name in this case.

2. **Answer: C**

   C is correct because influence is coming from a peer whose project competes for resources.

   A is incorrect because the project manager's peers are not from management.

   B and **D** are incorrect because Cosmo is neither the end user or supplier for project Teach the Congress, nor is he the team member or temporary worker from project Teach the Congress.

3. **Answer: C**

   C is correct because this is what the stakeholder engagement plan is for.

   A and **B** are incorrect because these are not documents, but tools and techniques.

   D is incorrect because the stakeholder register contains information about the stakeholders and not the management strategies about them.

4. **Answer: A**

   A is correct, and the others are not, because the stakeholder register document is the only one of the listed items that is not generated during the Plan Stakeholder Engagement process; it's generated during the Identify Stakeholder process instead.

5. **Answer: D**

   D is correct because managing and controlling stakeholder engagement in the core of stakeholder management.

   A and **C** are incorrect because you can neither manage nor control stakeholders at large; you can only engage them.

   B is incorrect because managing stakeholder expectations is a part of this knowledge area, not the whole single focus.

6. **Answer: A**

   A is correct, and the others are not, because project business documents are input to only the Identify Stakeholders process from the list, and Monitor Stakeholder Engagement is not even a standard process.

7. **Answer: B**

   B is correct, and the others are not, because the communications management plan is the only item out of the list that is input to all the processes of stakeholder management

8. **Answer: A**

   A is correct because work performance information, not performance reports, is an output of monitoring stakeholder engagement.

   B, C, and **D** are incorrect because they all can be outputs of monitoring stakeholder engagement.

9. **Answer: B**

   B is correct because project communications is an input to the Monitor Stakeholder Engagement process.

   A and **C** are incorrect because project communication is not used in these processes as a standard document.

   D is incorrect because there is no standard process named Distribute Information.

10. **Answer: D**

    D, and not the others, is correct because the salience model is used as a data presentation tool in the Identify Stakeholders process and is not used as a standard tool in any other listed processes.

Chapter 9

1. **Answer: E**

   All of these are communication skills that include listening. Without listening actively, you wouldn't be able to respond effectively.

2. **Answer: D**

   D, and not **A** or **B**, is the best answer because both basic and more complex interactive communication models have the feature of delivering messages and ensuring that they are understood.

   A is incorrect because the basic sender/receiver communication model does not have the feature of ensuring the message is understood.

3. **Answer: A**

   A is the correct answer because by trying to understand the phrases and terms, you are trying to decode the message, and those phrases and terms are acting as noise.

   B and **C** are incorrect because this is a message sent by the team member and is not a response.

   D is incorrect because we don't know in which language the message is written.

4. **Answer: D**

   D is the correct answer because stakeholder management strategies are in the stakeholder engagement plan, an input to communication planning.

   A, **B**, and **C** are incorrect because all these items are part of the communication management plan, an output of communication planning.

5. **Answer: A**

   A is the correct answer because work performance information is an output of the Monitor Communication Management process.

   B, **C**, and **D** are incorrect answers because all these items are part of the project communications, an output of the Manage Communication process.

6. **Answer: B**

   B is the correct answer because the issues log is not an input to the Plan Communications Management process, which determines the "how-tos" of communication.

   A is an incorrect answer because the issues log is used in planning stakeholder engagement to learn about the stakeholders issues.

   C and **D** are incorrect because the issues log is used in the Manage Communication and Monitor Communication processes to communicate information about issues to the stakeholders and monitor their communications.

7. **Answer: D**

   D is the correct answer, and the others are not, because communication, in singular, refers to the act of communicating, such as sending an e-mail message, while communications, in plural, refers to the artifacts of communication, such as meeting minutes and reports.

8. **Answer: C**

   C is the correct answer because project communications are an output of the Manage Communication process, and not an input.

   A, **B**, and **D** are incorrect because their items are input to the Manage Communication process; stakeholder engagement plan is so because it explains how to use appropriate stakeholder communication strategies to engage the stakeholders.

9. **Answer: B**

   B is correct because the process of Manage Communication significantly adds to the organizational process assets in the form of project reports, status reports, project presentations, stakeholder notifications, and other communication artifacts and records.

   A, **C**, and **D** are incorrect because these items will not certainly be modified.

10. **Answer: D**

    D is the correct answer because the Manage Communication process is used to distribute reports and other information to stakeholders.

    A, **B**, and **C** are incorrect because none of them is the standard name for any project management process.

11. **Answer: C**

    C is the correct answer because work performance data is the output of the Direct and Manage Project Work process.

A and **D** are incorrect because neither of these processes generates work performance data.

B is incorrect because no standard project management process is called Execute Project.

12. **Answer: D**

    D is the correct answer because processes in the monitoring and controlling process group, other than those in integration management, generate work performance information.

    A is incorrect because work performance information is an input to the Monitor and Control Project Work process that it uses to create performance reports.

    B and **C** are incorrect because neither Manage Communication nor Direct and Manage Project Work generate work performance information. Direct and Manage Project Work does generate work performance data.

13. **Answer: D**

    D is the correct answer and **A** and **B** are not because the Monitor Communication process is performed according to both the communication plan and the stakeholder engagement plan, and not the communication plan alone or stakeholder engagement plan alone.

    A is an incorrect answer because there is no standard project management plan called stakeholder management plan.

Chapter 10

1. **Answer: B**

   B is the correct answer because benchmarking is a quality planning technique that compares practices, products, or services of a project with those of some reference projects for the purpose of learning, improving, and creating the basis for measuring performance.

A is incorrect because you can always brainstorm, but it does not have to compare the results of similar activities.

C is incorrect because although it is a quality planning technique, it involves striking a balance between cost and benefit (which are not similar).

D is incorrect because quality metrics are not quality planning techniques; these are output items of the quality planning process.

2. **Answer: C**

   C is the correct answer because matrix diagrams are not used to explore the effects of defects; the tool for that would be cause and effect diagrams.

   A, **B**, and **D** are incorrect because all three are true statements about matrix diagrams.

3. **Answer: D**

   D is the correct answer because quality metrics are not used to find the key quality metrics important for project success; the tool for that would be matrix diagrams.

   A, **B**, and **C** are incorrect because all three are true statements about quality metrics.

4. **Answer: D**

   D is the correct answer, and the others are not, because work performance data is not the input to the Manage Quality process are the others are. The work performance data is input to the Control Quality process.

5. **Answer: B**

   B is the correct answer because the Manage Quality process incorporates the organization's quality policies and procedures into quality activities.

   A is incorrect because quality control is the process to verify project deliverables.

C is incorrect because Plan Quality is the process to identify quality requirements and standards and how to determine they are satisfied.

D is incorrect because there is not a standard quality process called Quality Assurance.

6. **Answer: A**

   A is the correct answer because the quality audit is a technique for performing the Manage Quality process.

   B and **C** are incorrect because the quality audit is a technique for performing quality assurance, whereas quality planning is about determining which quality standards are relevant to the project and how to satisfy them. Controlling quality is about verifying project deliverables.

   D is incorrect because there is no such quality management process as Quality Inspection.

7. **Answer: D**

   D is the correct answer because quality audits is a technique in the Manage Quality process.

   A and **B** are incorrect because auditing is a tool used in Manage Quality.

   C is incorrect because there is no standard process called Perform Quality Assurance.

8. **Answer: C**

   C is the correct answer, and the others are not, because the Ishikawa diagram is a tool used in *both* the Quality Control and Manage Quality processes to explore all the potential causes of a problem.

9. **Answer: A**

   A is the correct answer because a control chart is used to plot the results to determine whether they are within the acceptable limits.

   B is incorrect because a cause and effect diagram, also called an Ishikawa diagram or a fishbone diagram, is used to explore all the possible causes of a problem.

C is incorrect because inspections examine whether an activity, component, product, service, or result conforms to specific requirements.

D is incorrect because a scatter diagram is used to find the relationship between two variables, such as cause and effect.

10. **Answer: B**

    B is the correct answer because a cause and effect diagram can be used to identify the potential effects of defects; start fixing the defects with the worst and most unacceptable effects.

    A is incorrect because a control chart is used to plot the results to determine whether they are within acceptable limits.

    C is incorrect because inspection is used to determine if a product conforms to a standard.

    D is incorrect because a scatter diagram is used to find the relationship between two variables, such as cause and effect, or two causes.

11. **Answer: B**

    B is the correct answer because by using statistical sampling, you will pick a few samples of the code at random and get them reviewed. The results will represent the quality of the whole code, statistically speaking.

    A is incorrect because this is not an unreasonable demand.

    C is incorrect because testing tools cannot serve the purpose of a code review, and the customer wants the code review.

    D is incorrect because you have limited resources.

12. **Answer: C**

    C is the correct answer because quality control measurements are an output of controlling quality.

    A, **B**, and **D** are incorrect because all these items are included in the input to quality control.

13. **Answer: D**

    D is the correct answer because change control tools are a technique listed to be used in the Perform Integrated Change Control process.

    A, **B**, and **C** are incorrect because all of these are tools and techniques for performing the Quality Control process. Remember, cause and effect diagrams are also called Ishikawa diagrams and fishbone diagrams.

14. **Answer: D**

    D is the correct answer because flowcharts are not used in figuring out the frequency of defects from different attributes of a product during inspection; the tool for that would be the check sheets.

    A, **B**, and **C** are incorrect because all three are true statements about the flowcharts.

15. **Answer: A**

    A is the correct answer because there is no standard process named Perform Quality Assurance.

    B, **C**, and **D** are incorrect because all three are true statements about the mind-mapping technique.

16. **Answer: A**

    A is the correct answer.

    B is incorrect because Shewhart defined the plan-do-check-act cycle of quality management, and Deming modified it.

    C and **D** are incorrect because Crosby and Juan have made contributions to the knowledge base of quality management, but they did not define the plan-do-check- act cycle.

Chapter 11

1. **Answer: B**

    B is the correct answer because a risk can have a negative or a positive effect on a project.

    A, **C**, and **D** are incorrect answers because these are true statements about project risks.

2. **Answer: A**

   A is correct because the risk register is the output of the risk identification process, but it is not used as an input because it does not exist before this process.

   B, **C**, and **D** are incorrect because the risk register is an input item to perform qualitative risk analysis, perform quantitative risk analysis, plan risk responses, implement risk responses, and monitor risks.

3. **Answer: B**

   B is the correct answer because there is no standard technique called Delphi used in the Identify Risks process according to the PMBOK Edition 6.

   A, **C**, and **D** are incorrect answers because brainstorming is the data-gathering technique, and SWOT analysis and root-cause analysis are the data-analysis techniques, used for identifying risks.

4. **Answer: A**

   A is the correct answer because, depending upon the experience of the team, risks can be moved directly after the identification process to the quantitative analysis process without performing qualitative analysis.

   B, **C**, and **D** are incorrect answers because these are true statements.

5. **Answer: B**

   B is correct because building redundancy into a system is an example of mitigating the risk.

   A is incorrect because the risk can still happen because you have not changed the plan, such as moving the server center to some other city.

   C is incorrect because accepting a risk means no proactive action taken; this is not the case here.

   D is incorrect because you have not transferred the risk to a third party.

6. **Answer: D**

   D is correct because the risk has been transferred to a third party.

   A is incorrect because the risk can still happen because you have not changed the plan, such as eliminating the need for that part of the system.

   B is incorrect because mitigating the risk does not involve transferring the risk to a third party.

   C is incorrect because accepting a risk means taking no proactive action.

7. **Answer: C**

   C is correct because the numerical analysis of a risk is called quantitative risk analysis.

   A is incorrect because assigning numbers does not necessarily mean you are performing a Monte Carlo simulation, although it is one of the tools used to perform quantitative analysis.

   B is incorrect because qualitative analysis does not involve numerical analysis, such as EMV calculations.

   D is incorrect because risk response planning will be based on the results of risk analysis.

8. **Answer: D**

   D is correct because the probability of the risk is 50 percent, and the probability of the positive impact is 40 percent, so the total probability for the positive impact to happen is 0.5 X 0.4 = 0.2.

   EMV = Probability X Value of the outcome = 0.2 X $200,000 = $40,000

   A, **B**, and **C** are incorrect because they show wrong values for EMV.

9. **Answer: A**

   A is correct because the probability of the risk is 50 percent, and the probability of the positive impact is 40 percent, so the total probability for the positive impact to happen is 0.5 X 0.4 = 0.2.

   EMV = Probability X Value of the outcome = 0.2 X $200,000 = $40,000

Similarly, EMV for threat = 0.3 X \$50,000 = –\$15,000

Therefore, EMV for the risk = \$40,000 – \$15,000 = \$25,000

B, **C**, and **D** are incorrect because they show wrong values for EMV.

10. **Answer: D**

    D is correct because secondary risks are those risks that arise as a result of risk responses.

    A is incorrect because a residual risk is a risk that remains after a response has been performed.

    B is incorrect because, depending upon the nature of the secondary risk, it may have any priority.

    C is incorrect because the risk response will depend upon the analysis results of the risk.

11. **Answer: D**

    D is the correct answer because there is no such standard risk response named risk rejection.

    A, **B**, and **C** are all incorrect answers because these are valid risk responses.

12. **Answer: A**

    A is correct because SWOT is a risk-identification technique that identifies risks by examining the strengths, weaknesses, opportunities, and threats (SWOT) of a given project.

    B is incorrect because this is a wrong statement about SWOT.

    C and **D** are incorrect because SWOT is a technique used in risk identification, not in risk response planning or in quantitative risk analysis.

13. **Answer: C**

    C is the correct answer because you need to perform quantitative risk analysis to create a list of risks prioritized based on the total effect of each risk on the overall project objectives.

    A, **B**, and **D** are incorrect because these are the possible output items from qualitative risk analysis.

14. **Answer: D**

    D is the correct answer because the decision about a risk-related contractual agreement can be an output of risk response planning, not the quantitative risk analysis.

    A, **B**, and **C** are incorrect because all these are the possible output items from the quantitative risk analysis.

15. **Answer: D**

    D is the correct answer because risk-related recommendations for corrective actions are the output of the risk monitoring and controlling process.

    A, **B**, and **C** are incorrect because the outputs of these processes do not include recommended corrective actions.

16. **Answer: A**

    A is the correct answer because the recommendations for corrective and preventive actions and change requests must be processed through the Integrated Change Control process for approval.

    B, **C**, and **D** are incorrect because changes and recommendations are approved through the Integrated Change Control process.

17. **Answer: C**

    C is the correct answer because there is no document called the risk response management plan. The risk response–related activities are inserted into appropriate project and plan documents.

    A, B, and **D** are incorrect answers because they all are true statements.

18. **Answer: B**

    B is the correct answer because work performance information is an output of the Monitor Risks process, not its input.

    A, **C**, and **D** are incorrect because these items are included in the input of Monitor Risks.

Chapter 12

1. **Answer: D**

   D is the correct answer because the cost overrun in the firm fixed price (FFP) contract is borne by the seller.

   A is incorrect because in cost plus incentive fee (CPIF) the cost overrun is shared by the buyer and seller.

   B is incorrect because in time and materials (T&M), the increased cost due to the increased quantity of resources, such as work hours by a contractor, is borne by the buyer.

   C is incorrect because in a cost plus fixed fee (CPFF) contract, the cost overrun is paid by the buyer, as the seller is reimbursed for all allowable costs.

2. **Answer: A**

   A is the correct answer because it uses the rates for labor, and materials costs are fixed.

   B, **C**, and **D** are incorrect because the given scenario does not match the definitions of these contract types.

3. **Answer: B**

   B is the correct answer because SOW is an output of planning procurements.

   A, **C**, and **D** are incorrect answers because all of these are true statements.

4. **Answer: C**

   C is the correct answer because the cost overrun is paid by the buyer in cost plus fixed fee (CPFF) contracts.

   A is incorrect because the firm fixed price presents risk to both buyer and seller because the fixed price might turn out to be above or below the actual cost.

   B and **D** are incorrect because the fee in these cases does not rise with the increase of the actual cost.

5. **Answer: A**

   A is the correct answer because in this scenario the hourly rate sounds like a good option.

   B and **C** are incorrect because the reimbursable cost does not make sense in this case, and you don't have to add a fee to the cost.

   D is incorrect because you cannot correctly estimate the total price because you do not know how many programs are required.

6. **Answer: C**

   C is the correct answer because make-or-buy analysis is a technique used in the procurement planning process called Plan Procurements.

   A is incorrect because make-or-buy decisions are already made in the Conduct Procurements process.

   B is incorrect because there is no standard process called Administer Procurement.

   D is incorrect because Control Procurements is not the process in which make-or-buy decisions are made.

7. **Answer: D**

   D is the correct answer because seller proposal is a response to the bidding documents.

   A, **B**, and **C** are incorrect because all of these are bidding documents.

8. **Answer: C**

   C is the correct answer because the amount of work and hence the cost cannot be determined at this point. According to CPFF, all costs are reimbursed to the seller, and a fixed fee as a percentage of the original estimate is also paid.

   A is incorrect because the amount of work and hence the cost cannot be determined at this point.

   B is incorrect because a time and materials contract is used in a situation where both cost reimbursement and fixed-price features need to be applied. This is not the case here.

   D is incorrect because there is no such contract type as cost plus time.

9. **Answer: A**

   A is the correct answer and the others are wrong because Control Procurements uses work performance data generated by the Direct and Manage Project Work process, which itself generates change requests that would be processed through the Perform Integrated Change Control process.

10. **Answer: B**

    B is the correct answer because the deliverables accepted through procurement closure must go through project closure for handing them over to the customer or the sponsor.

    A, **C**, and **D** are incorrect because all these activities are part of the Control Procurement process.

11. **Answer: C**

    C is the correct answer because procurement contracts are closed to end the Control Procurements process.

    A, **B**, and **D** are incorrect because all these items are the output of the Close Project process.

12. **Answer: B**

    B is the correct answer because the deliverables must go through the Validate Scope process before going through the Close Project process, and before the scope can be validated, they must be verified through the Control Quality process.

    A is incorrect because the deliverables must be verified through the quality control process before their scope can be validated.

    C and **D** are incorrect because the Control Procurement process must be performed before you have all the accepted products go through the Close Project or Phase process.

13. **Answer: A**

    A, and not **B** or **C**, is the correct answer because sellers send proposals in response to buyers looking for sellers during the Conduct Procurement process.

    D is incorrect because there is no standard process called Close Procurement that is closed in the Control Procurement process.

Glossary

360-degree survey. A form of feedback from all around the entity being evaluated. It is not emphasized in the PMBOK 6th Edition, but it is a concept worth knowing.

activity. A component of project work.

activity definition. Define Activity is the process of identifying the specific activities that need to be scheduled and performed to produce the project deliverables.

activity duration. The time measured in calendar units between the start and finish of a schedule activity.

activity duration estimating. The process of estimating the time in work periods individually for each schedule activity required for activity completion. A work period is a measurement of time when the work is in progress; it is measured in hours, days, or months depending upon the size of the activity.

activity resource estimating. The process of estimating the types and amounts of resources that will be required to perform each schedule activity.

activity sequencing. The process of identifying and documenting the dependencies among schedule activities; which activities precede which.

actual cost (AC). The total cost actually incurred in performing the work for a project or a project activity until a specific point on the timescale.

affinity diagrams. A technique used to classify a large set of ideas into different groups for the purpose of reviewing or analyzing them.

alternatives analysis. A technique used to evaluate and rank the available options to perform project work.

P. Sanghera, *CAPM® in Depth*, https://doi.org/10.1007/978-1-4842-3664-2

analogous estimating. A technique used to estimate the duration or cost of an activity or project based on the duration of a similar activity in a previous project or the project itself.

assumption. A factor that you consider to be true without any proof or verification. Assumptions can appear in both the input and the output of various processes in some form.

assumption log. A project document that records and tracks all the project assumptions and constraints throughout the project.

assumptions analysis. A technique used to examine the validity of an assumption and thereby identify the risk resulting from the inaccuracy, inconsistency, or incompleteness of each assumption.

asynchronous communication. A communication in which the two communicating entities do not have to be present at each end of the communication line at the same time. E-mail is an example of asynchronous communication because when the sender of the e-mail pushes the Send button, the intended recipient of the e-mail message does not have to be logged on to the e-mail server.

baseline. A reference plan for project elements, such as schedule, scope, and cost, against which the actual project progress can be compared with to measure performance deviations. The reference plan can be the original or the modified plan.

benchmarking. Comparing practices, products, or services of a project with those of some reference projects for the purposes of learning, improvement, and creating a basis for measuring performance.

bid documents. All the documents used to get information from the sellers, such as quotations and proposals.

bottom-up estimation. A technique to estimate the cost and duration of a project or its parts by summing the estimates of components subordinate to it in the WBS.

brainstorming. A creative technique generally used in a group environment to gather ideas as candidates for a solution to a problem or an issue without any immediate evaluation of these ideas. The evaluation and analysis of these ideas happen later.

budget. The approved aggregation of cost estimates for a project or a part of it with a timeline assigned to it.

budget at completion (BAC). The total budgets authorized for performing the project work.

cause and effect diagram. A diagram used to explore all the potential causes (inputs) that result in a single effect (output), such as a problem or a defect. It may help to find the root cause of a problem.

change control board. A formal group of stakeholders with the authority to process change requests, which includes reviewing, approving, rejecting, or delaying change requests.

change control system. A collection of formal documented procedures that specifies how the project deliverables and documents will be changed, controlled, and approved.

change request. A request for deviating from the project plan or related policies or procedures, such as modifying scope, schedule, or cost. Change requests may include recommendations for corrective and preventive actions.

claim. An assertion, demand, or request made by a buyer against the seller or vice versa for consideration or compensation under the terms of a legal contract.

close project or phase. A process used to finalize all activities across all of the process groups to formally close the project or a phase of it.

code of accounts. A numbering system used to uniquely identify each component of a WBS.

communication management plan. A document that describes the communication needs and expectations of the project and how these needs and expectations will be met.

Communication requirement analysis. A technique used to determine the information needs of the project stakeholders by using methods such as workshops, interviews, and from the lessons learned database from similar projects.

confidence level. A statistical term that refers to the certainty attached to an estimate and is often represented in percentage form, such as a 95 percent confidence level.

configuration management. Refers to controlling the characteristics of a product, a service, or a result of a project. It includes documenting the features of a product or a service, controlling and documenting changes to the features, and providing support for auditing the products for conformance to requirements.

constraint. A restriction (or a limitation) that can affect the performance of the project.

contingency. A future event or condition that is possible but cannot be predicted with certainty. In this case, an action will be contingent upon the condition—that is, the action will be executed only if the condition happens.

contingency reserve. Funds or time reserved in addition to the calculated estimates to deal with contingencies, such as uncertainties in the duration used in the schedule and the cost used in the budget.

context diagrams. Visual display of how different aspects of a system and different kinds of uses interact with each other.

contract. A mutually binding agreement between a buyer and a seller that obligates the seller to provide the specified product, service, or result and obligates the buyer to make the payment for it.

control. To analyze the performance of the project and make and implement recommendations for corrective actions or other changes to bring the project back on track.

control account. A node in the WBS that acts as a management control point where scope, schedule, and actual cost are integrated and compared to the earned value to measure project performance.

control chart. A chart or diagram used to monitor whether the variance of a specified variable is within the acceptable limits dictated by quality control.

COQ. Cost of quality; the total cost of quality-related efforts throughout the product lifecycle.

corrective actions. Actions recommended for execution in the future in order to bring project performance back in line with the project management plan.

cost baseline. The planned budget for the project over a time period, used as a basis against which to monitor, control, and measure the cost performance of the project. The cost performance is measured by comparing the actual cost to the planned cost over a time period.

cost performance index (CPI). A measure of the cost efficiency of a project calculated by dividing earned value (EV) by actual cost (AC).

cost variance (CV). A measure of cost performance obtained by subtracting actual value (AC) from earned value (EV). A positive result indicates good performance, whereas a negative result indicates bad performance.

CPFF. Cost plus fixed fee; a contract type.

CPIF. Cost plus incentive fee; a contract type.

CPPC. Cost plus percentage of cost; a contract type.

crashing. A project schedule compression technique used to decrease the project duration with minimal additional cost. A number of alternatives are analyzed, including the assignment of additional resources.

critical path. The longest path (sequence of activities) in a project schedule network diagram. Because it is the longest path, it determines the duration of the project.

critical path method (CPM). A schedule network analysis technique used to identify the minimum project duration and schedule's flexibility and the critical path of the project schedule network diagram.

decision tree analysis. A technique that uses a decision tree diagram to choose from different available options to take; each option may be represented by a branch of the tree. EMV analysis is done along each branch, which helps one make a decision about which option to choose.

decode. To convert the received message from the media back into useful ideas and thoughts.

decomposition. A planning technique to subdivide the project scope, including deliverables, into smaller and smaller, manageable tasks called *work packages*.

defect. An imperfection or deficiency that keeps a component from meeting its requirements or specifications. A defect is caused by an error (problem) and can be repaired by fixing the error.

deliverable. A unique and verifiable product, a capability to provide a service, or a result that must be produced to complete a project or a process or phase of the project.

develop team. A process of improving the team competence at individual member level and at team level, and to improve the overall team environment in order to improve the project performance.

distribute information. The process of making information available to stakeholders according to the project management plan.

earned value (EV) or budgeted cost of work performed (BCWP). The value of the actually performed work expressed in terms of the approved budget for a project or a project activity for a given time period.

earned value management (EVM) or earned value technique (EVT). A management methodology and technique to measure project progress by comparing integrated measures of scope, schedule, and cost with the planned performance baseline.

emotional intelligence. The ability to detect, perceive, access, and manage the emotions of self, other peoples, and different group of peoples.

encode. To convert thoughts and ideas into a message that could be transmitted through the media.

enterprise environmental factors. Factors internal or external to the performing organization that can influence the project's success, such as the organization's culture, infrastructure, existing skill set, market conditions, and project management software. These are input to both the project charter and the preliminary project scope statement.

estimate at completion (EAC) at budgeted rate. The estimate from the current point in time of how much it will cost to complete the entire project or an entire project activity for which the BAC is given. The value of EAC is obtained by adding the value of ETC at the budgeted rate to AC.

estimate at completion (EAC) at current CPI. The estimate from the current point in time of how much it will cost to complete the entire project or an entire project activity for which the BAC is given. The value of EAC is obtained by adding the value of ETC at the current CPI to AC.

estimate to complete (ETC) at budgeted rate. The expected cost, estimated by assuming future performance will be at the budgeted rate, to complete the remaining work for the project or for a project activity.

estimate to complete (ETC) at present CPI. The expected cost, estimated by assuming the future performance will be at the current CPI, to complete the remaining work for the project or for a project activity.

expected monetary value (EMV) analysis. A statistical technique used to calculate the expected outcome when there are multiple possible outcome values with probabilities assigned to them.

experiment design. A statistical method that can be used to identify the factors that can influence a set of specific variables of a product or a process under development or in production.

fast tracking. A project schedule compression technique used to decrease the project duration by performing project phases or some schedule activities within a phase simultaneously when they would normally be performed in sequence.

float time. The positive difference between the late start date and the early start date of a schedule activity without delaying the schedule.

flowchart. A diagram that depicts the inputs, actions, and outputs of one or more processes in a system.

FP. Fixed price; a contract type.

Gantt Chart. A bar chart used to display project schedule with X-axis representing time and Y-axis representing activities drawn as horizontal bars; each bar starting from start date and stopping at end date of the activity.

histogram. A bar chart that shows a distribution of variables.

incentive fee. A set of financial motives for seller relation to cost, schedule, and performance; such as a bonus.

initiating process group. A process group that contains two processes: develop project charter and identify project stakeholders.

inspection. A technique to examine whether a work project or result conforms to specific standards.

issue. An item or a matter that is under discussion or dispute and for which there are most likely opposing views and disagreements among the stakeholders.

issue log. A tool such as a document to manage issues; includes opening, modifying, tracking, documenting, and resolving the issues.

knowledge area. A knowledge area in project management is defined by its knowledge requirements related to managing a specific aspect of a project, such as cost, by using a set of processes. PMI recognizes a total of ten knowledge areas, such as cost management and resource management.

lag. A technique to modify a dependency relationship by delaying the successor activity. For example, a lag of five days in a finish-to-start relationship means the successor activity cannot start until five days after the predecessor activity has ended.

lead. A technique to modify a dependency relationship by accelerating the successor activity. For example, a lead of five days in a finish-to-start relationship means the successor activity can start up to five days before the finish date of the predecessor activity.

logical relationship. A dependency between two project schedule activities or between a schedule activity and a schedule milestone.

manage project knowledge. A process of creating new knowledge by using the existing knowledge to meet the project objectives.

management reserve (MS). The part of project budget or schedule time not included in the performance measurement baseline and reserved to deal with unseen missed work within the project scope.

managing stakeholder engagement. A process used for communicating and working with stakeholders to stay on the same page as them regarding the project requirements by addressing their needs and issues as they arise and appropriately involve them in the project.

methodology. A system of procedures and techniques practiced in a discipline to accomplish a task. For example, risk management methodology is used in the discipline of project management to determine how risk management processes will be performed, etc.

milestone. A significant point (or event) in the life of a project, such as the delivery of a project outcome.

mind mapping. A technique to put all the ideas from multiple brainstorming session into a single map to expose the similarities and differences among them; this will also help to create new ideas.

mitigation. The process of taking action to reduce or prevent the impact of a disaster that is expected to occur.

model. A set of rules to describe how something works, which takes input and makes predictions as output.

monitor. To collect project performance data, convert the data to performance measurements and this performance information.

monitor risks. To track identified risks, identify new risks, monitor residual risks, implement risk response plans, and evaluate risk management processes.

Monte Carlo simulation. An analysis technique that randomly generates values for uncertain elements (that is, variables) and takes them as input to a model to generate output to represent various project output scenarios.

organization. A group of individuals organized to work for some purpose or mission.

organizational process assets. The processes and process-related assets of the organizations participating in the project that can be used to perform the project successfully, such as processes, plans, templates, guidelines, knowledge base, and policies and procedures.

parametric estimating. A quantitative technique used to calculate the cost or activity duration using historical data and appropriate project parameters.

performance measurement baseline (PMB). An approved integrated plan consisting of scope, schedule, and cost baselines used to make performance measurements by comparing the actual project result against this baseline.

performance report. A document or a presentation that presents the project progress in terms of status and some parameters, such as earned value management parameters, based on the analysis of work performance information/data.

performing organization. The organization that is performing the project.

planning component. A WBS component at the bottom level of a branch of the WBS hierarchy for which some planning can be performed.

planning package. A WBS component that is below the control account and has a well-defined work content but does not yet have a detailed schedule.

portfolio. A set of projects, programs, subsidiary portfolio, and operations managed in a coordinated fashion to obtain business objectives in the strategic plan of the organization.

portfolio management. The centralized management of one or more portfolios, which includes identifying, authorizing, prioritizing, managing, and controlling projects.

precedence diagramming method (PDM). A technique used to construct a project schedule network diagram in which a node (a box) represents an activity and an arrow represents the dependency relationship.

preventive actions. Directions to perform an activity that will reduce the probability of negative consequences associated with project risks. These preventive actions are recommended by the QA process during process analysis.

process. A set of interrelated activities performed toward obtaining a specified set of products, results, or services. Processes have one or more input items that are converted into one or more output items.

process analysis. A technique used to identify the needed improvements in a process by examining the constraints, invaluable activities, inefficiencies, and other problems.

procurement. Refers to obtaining (purchasing or renting) products, services, or results from outside the project team to complete the project.

procurements. Purchases and acquisitions that are needed to complete the project but that cannot be produced by the in-house project team.

procurement audit. A structured review of the procurement contracts and process for completeness, accuracy, and effectiveness with the purpose of identifying successes and failures from the planning.

procurement management. The execution of a set of processes used to obtain products, services, or results from outside the project team to complete the project.

procurement management plan. A document that describes how procurements will be managed.

product scope. Features and functions that characterize a product, service, or result to be delivered by the project.

program. A set of related projects, subsidiary programs, and related activities managed in a coordinated fashion to improve overall efficiency and effectiveness that may not be obtained by managing the projects individually.

program management. The centralized coordinated management of a specific program to achieve its strategic goals, objectives, and benefits.

program management office (PMO). An entity in an organization that is responsible for providing centralized coordinated support to the program managers managing programs and unrelated projects.

progressive elaboration. A technique used to continuously improve a plan by working out more details and providing better accuracy as more-detailed and -specific information becomes available as the project progresses.

project business documents. Refers to two documents: business case and benefit management plan.

project calendar. A calendar of working days or shifts used to establish when a schedule activity can be performed. A calendar typically specifies holidays and weekends when a schedule activity cannot be performed.

project charter. A document containing the high-level information of the project issued by the project initiator, such as the sponsor, that formally authorizes the project, names the project manager, and authorizes the project manager to use the organization's resources for the project.

project interfaces. The formal and informal boundaries and relationships among team members, departments, organizations, or functions. An example might be how the development department and the QA department interact with each other while working on the same project.

project management information system (PMIS). An information system that consists of tools used to store, integrate, and retrieve information, such as the outputs of the project management processes. This can be used to support all stages of the project from initiating to closing.

project management plan. An approved document that describes how the project will be executed, monitored and controlled, and closed.

project performance. Measure of actual project progress against planned progress.

project/product transition. Handing over of the project output to the appropriate party.

project schedule. A schedule that consists of planned dates for performing schedule activities and meeting schedule milestones.

project schedule network diagram. A schematic display of logical relationships among the project schedule activities. The time flow in these diagrams is from left to right.

project scope. The work that must be performed (and only that work) to deliver products, services, or results with specified features that were promised by the project. The project scope draws boundaries around the project—what is included and what is not.

project scope creep. Changes applied to the project scope without going through the approval process, such as the integrated change control process.

qualitative risk analysis. A process used to prioritize risks by estimating the probability of their occurrence and their impact on the project.

quality. The degree to which a set of characteristics of project deliverables and objectives fulfills the project requirements.

quality audit. A structured and independent review to determine whether project activities comply with the policies, processes, and procedures of the project and the performing organization.

quality control. Monitoring the results of executing the quality management activities to assure the project outputs are complete and accurate as planned and recommending necessary changes and actions to conform with the quality plans.

quality management plan. A management plan that describes how the project management team will implement the quality policy of the performing organization for the specific project.

quality metrics. An operational criterion that defines in specific terms what something (such as a characteristic or a feature) is and how the quality control process measures it.

quality planning. The process of identifying the quality standards relevant to the project at hand and determining how to satisfy these standards.

quality policy. The policy stating high-level direction of an organization with respect to quality, and applied to actions in project quality management.

quantitative risk analysis. A process used to perform numerical analysis to estimate the effect of each identified risk on the overall project objectives and deliverables, and prioritize the risks accordingly.

RAM. Responsibility assignment matrix; a matrix used to specify the relationships between schedule activities, roles to perform those activities, and team members assigned to the roles.

requirement. A condition, characteristic, or capability that a specific outcome of the project must have.

residual risk. A risk that remains after the risk response has been performed.

resource breakdown structure (RBS). A hierarchical structure of resource types required to complete the schedule activities of a project.

risk. An uncertain event or condition that, if it occurs, has a positive or negative effect on meeting the project objectives.

risk breakdown structure (RBS). A hierarchical structure that breaks down the identified risk categories into subcategories. In developing this structure, you will end up identifying various areas and causes of potential risks.

risk identification. A process used to identify the risks for a given project and record their characteristics in a document called the *risk register*.

risk management plan. A document that describes how risk management will be structured and performed for the project at hand. It becomes part of the project management plan.

risk management planning. A process used to determine how to approach, plan, and execute risk management activities for a given project. This process produces the risk management plan.

risk register. A document that contains the detailed information on each identified risk.

risk trigger. An alert that indicates a risk event has occurred or is about to occur.

role. A defined function that contains a set of responsibilities to be performed by a team member, such as a programmer or a tester.

rolling wave planning. A case of progressive elaboration in which the work to be performed now and in the nea future is planned in detail, while the work to be performed.

scatter diagram. A diagram used to show the pattern of the relationship between two variables—an independent variable and another variable that depends on the independent variable.

schedule activity. A scheduled task (component of work) performed during the lifecycle of a project.

schedule baseline. A specific version of the project schedule developed from the schedule network analysis and the schedule model data. This is the approved version of the schedule, with a start date and an end date, and it is used as the basis against which the project schedule performance is measured.

schedule compression. A technique used to shorten the schedule without changing the scope.

schedule development. The process of creating the project schedule by analyzing schedule activity sequences, schedule activity durations, resource requirements, and schedule constraints.

schedule milestone. A significant event in the project schedule, such as the completion of a major deliverable.

schedule network analysis. A technique used to generate a project schedule by identifying the early and late start and finish dates for the project.

schedule performance index (SPI). A measure of the schedule efficiency of a project calculated by dividing earned value (EV) by planned value (PV).

schedule Variance. A schedule performance variable measured by subtracting the planned values (PV) from the earned value (EV).

schedule revision. An update to the project schedule that includes changing the project start date, end date, or both.

scope baseline. The approved project scope, which includes the project scope statement, the WBS, and the corresponding WBS dictionary.

scope definition. The process used to develop the detailed project scope statement.

scope planning. The process of developing the project scope management plan.

secondary risk. A risk that arises as a result of implementing a risk response.

simulation. Any analytical method used to imitate a real-life system.

stakeholder register. A document that identifies the project stakeholders and the relevant information about them.

statistical sampling. Randomly selecting a part of the population for study.

strengths, weaknesses, opportunities, and threats (SWOT) analysis. An analysis technique used to examine a given project from the perspectives of its strengths, weaknesses, opportunities, and threats of the project or the organization.

subprojects. Parts of the main project that are independent enough that each can be performed by separate project teams.

synchronous communication. Communication in which both the sender and the receiver have to be present at the same time, such as face-to-face project meetings and teleconferencing.

T&M. Time and material; a contract type.

variance. A measurable deviation in the value of a project variable, such as cost, from a known baseline or expected value.

variance analysis. A technique used to assess the magnitude of variation in the value of a variable (such as actual cost from the baseline or expected value), determine the cause of the variance, and decide whether corrective action is required.

verify scope. The process of formally accepting the completed project deliverables.

virtual team. A team of members working on the same project with few or no face-to-face meetings. Various technologies, such as e-mail, video conferencing, and the World Wide Web, are used to facilitate communication among team members.

war room. A conference room used for project team meetings.

work breakdown structure (WBS). A deliverable-oriented hierarchical structure that displays the decomposition of deliverables into work that must be performed to accomplish the project objectives and create the project deliverables.

work package. A deliverable or a task at the lowest level of each branch of the WBS, for which the duration and cost, etc, can be managed.

workaround. A response to a negative risk that has occurred. A workaround is based on a quick solution and is not planned in advance of the risk-occurrence event.

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P. Sanghera, *CAPM® in Depth*, https://doi.org/10.1007/978-1-4842-3664-2

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